Naval Systems Engineering Guide

October 2004

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **OCT 2004**	2. REPORT TYPE	3. DATES COVERED **00-00-2004 to 00-00-2004**
4. TITLE AND SUBTITLE **Naval Systems Engineering Guide**		5a. CONTRACT NUMBER
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Systems Engineering Steering Group,Washington,DC**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR’S ACRONYM(S)
		11. SPONSOR/MONITOR’S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**295**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

DEPARTMENT OF THE NAVY

NAVAL AIR SYSTEMS COMMAND, PATUXENT RIVER, MD 20670-1547 NAVAL
SEA SYSTEMS COMMAND, WASHINGTON NAVY YARD, DC 20376-4065
NAVAL SUPPLY SYSTEMS COMMAND, MECHANICSBURG, PA 17055-0791
SPACE AND NAVAL WARFARE SYSTEMS COMMAND, SAN DIEGO, CA 92110-3127
MARINE CORPS SYSTEMS COMMAND, QUANTICO, VA 22134-6050

NAVAIR
4400
Ser00/118

NAVSEA
4400
Ser 007

NAVSUP
4400
Ser00/

SPAWAR
4400
Ser00/

MARCORSYSCOM
4400
Ser00/

MEMORANDUM OF UNDERSTANDING VS-MOU-20
AMONG
NAVAL AIR SYSTEMS COMMAND
NAVAL SEA SYSTEMS COMMAND
NAVAL SUPPLY SYSTEMS COMMAND
SPACE AND NAVAL WARFARE SYSTEMS COMMAND
MARINE CORPS SYSTEMS COMMAND

Subj: MEMORANDUM OF UNDERSTANDING FOR AN INTRODUCTION AND PROMULGATION OF THE NAVAL SYSTEMS ENGINEERING GUIDE

Ref: (a) Under Secretary of Defense Memorandum, Policy for Systems Engineering in DoD, of20Feb2004

1. By reference (a), the Acting Under Secretary of Defense (Acquisition, Technology and Logistics) signed into policy the requirement that "All programs responding to a capabilities or requirements document shall apply a robust Systems Engineering (SE) approach that balances total system performance and total ownership costs within the family-of-systems, system-of-systems context. Accordingly, a SE Plan shall be developed for Milestone Decision Authority approval in conjunction with each Milestone review". SE must be embedded in program planning and performed across the entire acquisition life cycle. SE provides the integrating technical processes to define and balance system performance, cost, schedule, and risks.

2. To assist Naval programs in thoroughly implementing SE in their programs, we have developed the Naval Systems Engineering Guide (NSEG). This document is based on the EIA-632 and expanded by the naval systems commands. The NSEG provides the tools needed to develop the required SE Plan and to implement the necessary SE discipline and is accessible on the Defense Acquisition University website below:

http://pmcop.dau.mil/simulifv/ev.php?ID=1204 201&ID2=DO TOPIC

Subj: MEMORANDM OF UNDERSTANDING FOR AN INTRODUCTION AND PROMULGATION OF THE NAVAL SYSTEMS ENGINEERING GUIDE

3. This Virtual SYSCOM memorandum of understanding will assist in maximizing our performance in supporting the Fleet and realizing the potential capabilities of our products.

W. B. MASSENBURG, Commander,
Naval Air Systems Command

A. W. LENGERICH 07 July 05
CQMNAVSEA (Acting)

DTK, STONE, Commander,
"Naval Supply Systems Command

W. D. RODRIGUEZ, Commander
Space and Nayal **Warfare** Systems **Command** (Acting)

WII
-LIAJvlD. CATTO, Commanding General,
Marine Corps Systems Command

Table of Contents

Table of Contents (cont.)

List of Figures

List of Figures (cont.)

Page
Number

Introduction

Executive Summary

The Naval Systems Engineering Guide is provided to help ensure the systems we develop for the fleet are affordable, operationally effective and suitable, and can be a timely solution to satisfy user needs at an acceptable level of risk. This Guide defines the systems engineering (SE) requirements and tasks; their implementation and products; and explains the tools and techniques used throughout a product life cycle. This Guide satisfies the DoD requirement for having a documented SE process, and emphasizes the relationship between the technical management process and the SE process. It documents a common Naval Systems Engineering Process that has been accepted by the Naval Virtual Systems Command.

The purpose of this Guide is to characterize the contents of the SE discipline, to promote a consistent and common view of SE across the Navy, to clarify the boundary of SE with respect to other disciplines, and to provide a foundation for curriculum development and SE certification. This Guide consists of information and 33 required or *normative* processes. This Guide describes a rigorous process to assist the systems engineer in defining, performing, managing, and evaluating SE efforts in Naval acquisition and technology development programs. The intended audience is the new systems engineer, an engineer in another discipline that needs to perform some SE functions, or a more-experienced systems engineer who needs a convenient reference. The hyper-linking to the imbedded reference material makes it very convenient using the electronic version of this Guide. The intent is to provide enough information for the user to determine whether a given process activity is appropriate in supporting the objective(s) of the program or project they support, and how to go about implementing the process activity.

The framework for this Guide is an industry standard, ANSI/EIA-632, *Processes for Engineering a System*. The standard was developed to replace the SE military standard, MIL-STD-499 as part of the 1994 DoD Acquisition Reform initiative prescribing the use of “performance-based” acquisition specifications and the substitution of the standards and practices used in the commercial marketplace for military specifications and standards. The Naval Systems Engineering Steering Group (SESG), comprised of members from NAVAIR, NAVSEA, MARCOR, and SPAWAR, provided the common and unique SE requirements and implementation approach for the various Naval development and acquisition programs. Periodic updates are planned to implement continuous process improvement, based upon feedback from programs / contractors, by the Naval SESG which maintains this Guide.

It is expected that programs would adopt the process in this Guide and tailor the specific requirements to fit their program based upon where the program is in terms of life cycle, technology risks, and funding levels. Though there is an attempt made to show how products are affected by what SE process, and the impact to the product as the product move through the acquisition phases, the emphasis is on specifying the requirements for the processes rather than phases. Since selection of an acquisition phase is dependent on the particular application, and to some extent organizational structure, specifying temporal flow is currently outside the scope of this Guide.

Background

In June 1994, a working group of industry associations, the International Council on Systems Engineering (INCOSE), and the Department of Defense developed an interim standard for the engineering of systems. This effort was led by the G-47 Committee on Systems Engineering of the Electronic Industries Alliance (EIA). The EIA/IS 632 was intended to provide a standard for use by commercial enterprises, as well as government agencies and their development contractors.

In April 1995, a formal working group was established under Project PN-3537 and with EIA and INCOSE sponsorship to generate and release this full Standard. The joint working group decided that it would best serve U.S. industry to develop a “top-tier” standard applicable across all industry sectors and technology domains. As

a result, the contents of this Guide are an abstraction of the essential features of the engineering practices described in the interim version of this Standard.

In July 1999, the Naval Air Systems Command Systems Engineering Process Working Group (NAVAIR SEPWG) was established to develop a NAVAIR guide to EIA-632. In summer 2003, the Naval Systems Engineering Steering Group (SESG), comprised of members from NAVAIR, NAVSEA, MARCOR, and SPAWAR, was established to provide the common and unique SE requirements and the implementation approach for the various Naval development and acquisition programs in this Guide.

This Guide is consistent with ISO 9000 in that it provides processes that can be adopted by enterprises for engineering systems. Appendix A is normative. Appendices B through J are informative. Appendices beyond F were added specifically to address Naval acquisition and development resources.

Compliance

Use of this of this Guide is provided as a resource for documenting the Naval information process and is compliant with DoD directives on having a documented SE process. The processes of this Guide should be referenced in the Systems Engineering Plan (SEP) as required by DoD directives.

Users

This document is the property of the US Navy and is being made available to Naval personnel. Since it contains EIA-632 copyright material, arrangements have been made that enable customers, contractor personnel, partners, and non-governmental team members are able to obtain and use this document within their respective organizations.

This Guide assumes that the reader has a basic understanding of systems engineering as addressed in the DAWIA Systems 201 and SYS 301 courses, and/or other graduate level SE courses. It builds on those fundamentals, and concentrates on the systems engineering process and the relationship and interdependence of these process steps. This Guide attempts to use the most common terminology of the SE community in order to facilitate better communication.

Document Organization

The Guide is organized as follows:

Section 1	*Scope*	states the purpose of this Guide and defines the particular processes to which it is intended to apply.
Section 2	*Normative references*	lists other standards that are so referred to in the text as to make them indispensable in applying this Guide.
Section 3	*Definitions and acronyms*	defines special use terms and acronyms.
Section 4	*Processes*	contains the requirements for the processes that are central to engineering a system. Representative tasks associated with each process are defined.
Section 5	*Application context*	describes the context in which the processes of this Guide are applied.
Section 6	*Application key concepts*	describes key concepts related to applying the processes of Section 4 to generate and integrate the layers of end products and enabling products needed for engineering a system.
Appendix A	*Glossary*	gives definitions for words that are used in a specific technical way in the body of the Guide. Only those terms for which the normal dictionary definition does not suffice are included.
Appendix B	*Enterprise-based Life Cycle*	describes the management-life-cycle phases in which a system, or portion thereof, is incrementally engineered.
Appendix C	*Process Task Outcomes*	provides expected outcomes for the representative tasks identified in Section 4.
Appendix D	*Planning Documents*	lists typical source, technical, and other documents related to engineering a system and their contents.
Appendix E	*System Technical Reviews*	describes the necessary technical reviews for assessing progress against technical plans and requirements, and for assessing planned tasks.
Appendix F	*Process Relationships*	defines different types of requirements and the relationship between these types and the logical and physical solution representations.
Appendix G	*Engineering Specialty References*	collection of engineering specialty references listed by technical discipline.
Appendix H	*Naval Process Flow Diagrams*	collection of process flow diagrams summarizing the 33 Sub-processes
Appendix I	*Naval Acronyms*	wording for acronyms
Appendix J	*Naval References*	reference listing with hyperlinks to electronic versions of documentation

1 Scope

1.1 Purpose

The purpose of this Guide is to characterize the contents of the SE discipline, to promote a consistent and common view of SE across the Navy, to clarify the boundary of SE with respect to other disciplines, and to provide a foundation for curriculum development and SE certification.

1.2 Applicability

This Guide defines processes for engineering a system. These have been organized into five groups as shown in Figure 1.1. The process covered in the legacy MIL-STD-499B is noted in the figure.

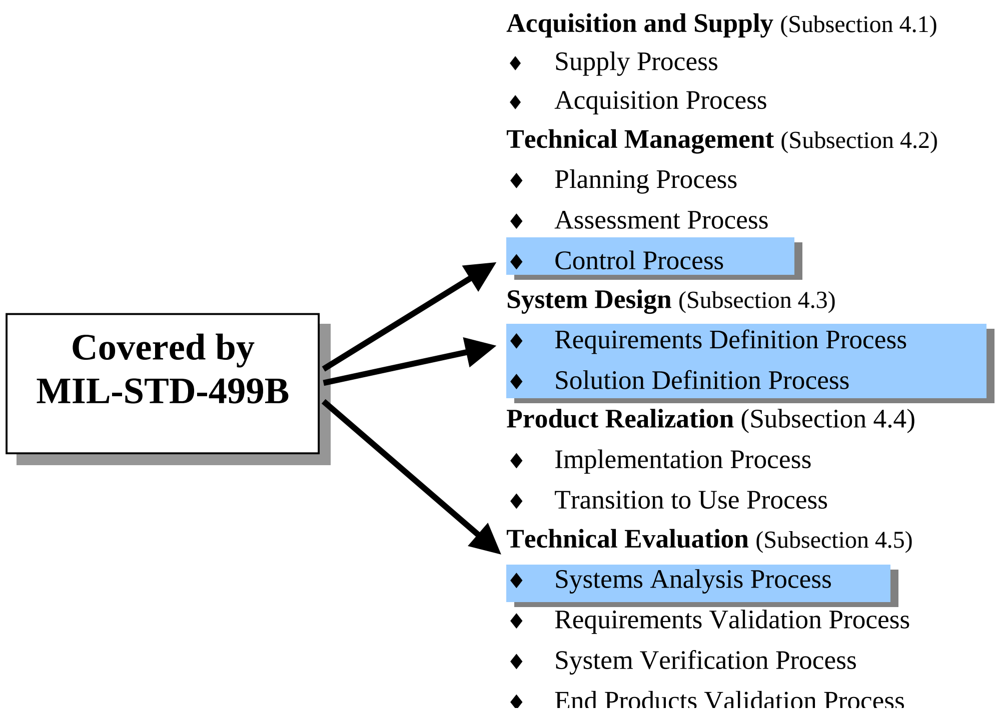


Figure 1.1 – Fundamental processes for engineering a system with MIL-STD-499B comparison

The applicability of EAI 632 and this Guide with respect to enterprises and projects is shown in Figure 1.2.

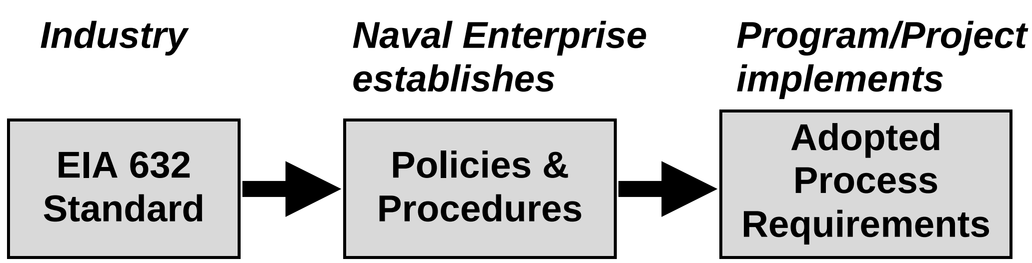


Figure 1.2 – Application of this Guide

The EAI 632 standard specifies accepted practices used for engineering systems but does not specify the details of "how to" implement process requirements. Nor does it specify the methods or tools a developer would use to

implement the process requirements. It is intended that the developer select or define methods and tools that are applicable to the development, and that are consistent with enterprise policies and procedures.

In this Guide, the Naval policies and procedures were added to describe "how to" with respect to Naval programs. The intent is to provide the Systems Engineer with insight into how Naval Systems Engineering processes fit into the overall EIA-632 systems engineering framework. Additionally, whenever possible, information is provided regarding the inputs, outputs, entry criteria, exit criteria, references, agents, tools and methods that Naval engineering may use to accomplish each sub-process. This Guide also specifies name, format, content, structure, or medium for documentation for NAVAIR programs. Since selection of an acquisition phase is dependent on the particular application, and to some extent organizational structure, specifying temporal flow is currently outside the scope of this Guide.

It is expected that programs would adopt the process in this Guide and tailor the specific requirements to fit their program based upon where the program is in terms of life cycle, technology risks, and funding levels. The emphasis is on specifying the requirements for the processes rather than phases.

2 Normative references

The normative references of this Guide are the 33 processes constituting Section 4 of this document. These are the accepted practices used for engineering systems in DoD acquisition programs. These normative processes were the processes adapted from EIA 632. The systems engineering process timeline as it applies to the DoD acquisition life cycle is provided in Figure 3a. Additional applicable DoD references have been cited in each sub-process for the execution of the specific process.

3 Definitions and acronyms

3.1 Key terms

Definitions for special use of terms are contained in **Appendix A**, Glossary.

3.2 Acronyms

Acronyms used in this Guide are contained in **Appendix I**, Acronyms.

3.3 Terminology

The word ***shall*** identifies mandatory provisions of this Guide. The word ***should*** identifies recommended provisions of this Guide. The word ***may*** identifies permissive provisions of this Guide.

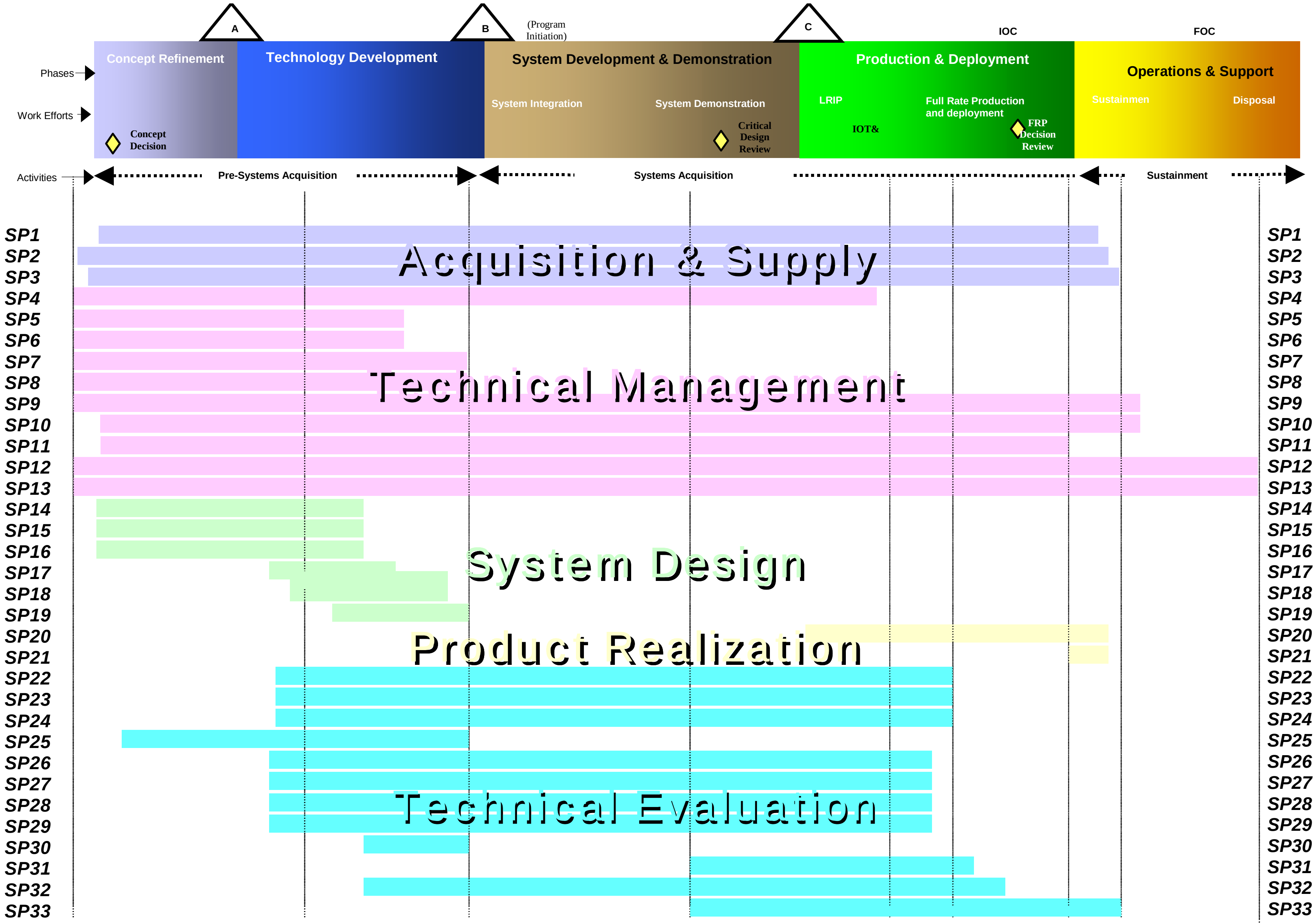


Figure 3a – Systems engineering process timeline

4 Processes

This section provides sub-processes for processes used in engineering a system and is applicable to any product development regardless of its place in the hierarchy of the system structure (see Section 6) or the enterprise-based life-cycle phase (see Appendix B). The processes are applicable to the engineering or reengineering of the end products that make up a system, as well as the development of enabling products required to provide life-cycle support to system end products. Figure 4a shows the relationships between the processes of this Guide.

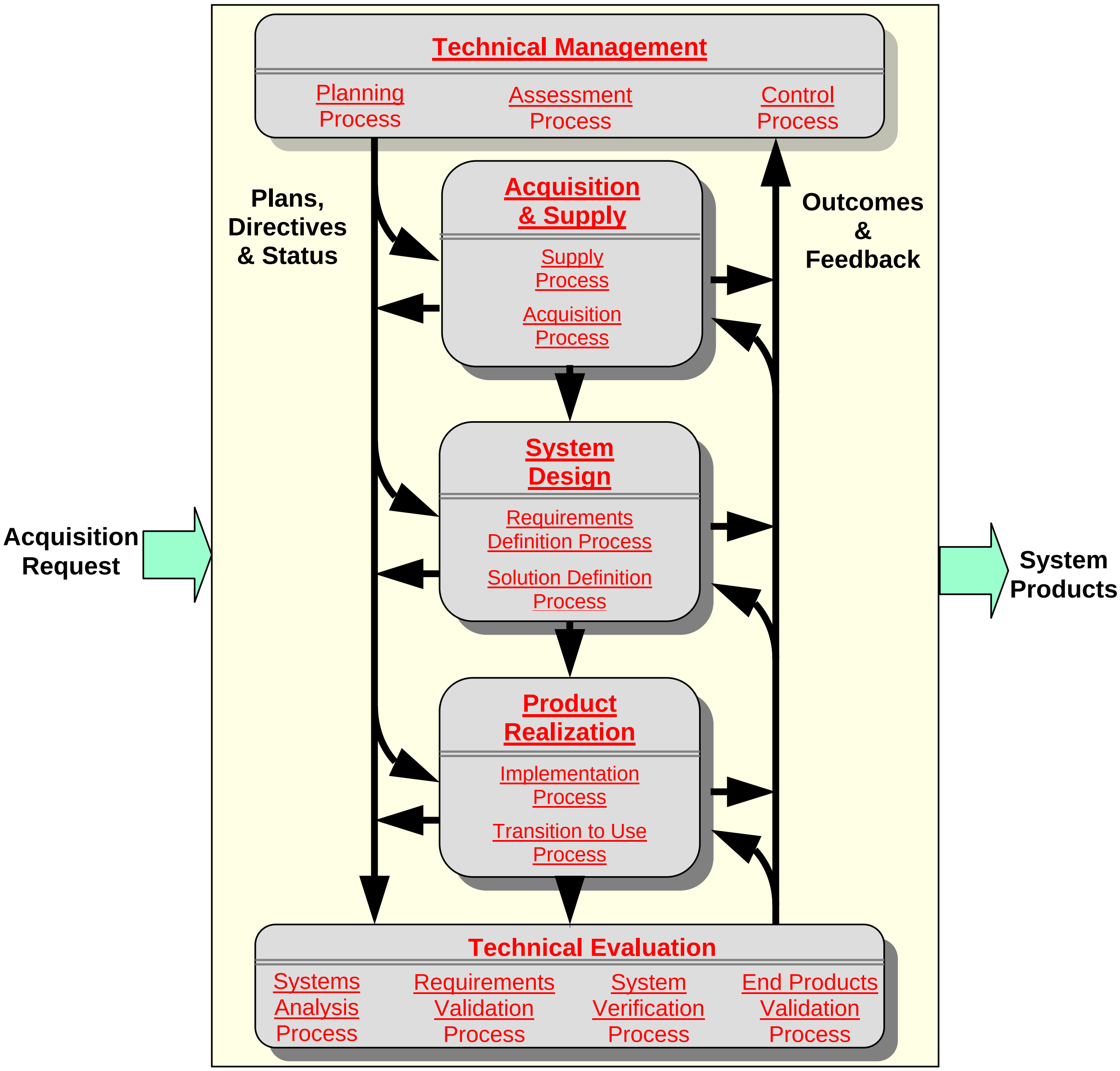


Figure 4a – Relationship of processes for engineering a system

NOTES
1 The application of the processes shown in Figure 4a is discussed in Section 6. Appropriate processes of Figure 4a are applied recursively and iteratively to define the system products of the system hierarchy from the top down, and then, to implement and transition the system products, from the bottom up to the user or customer.
2 Although the Sub-processes in this Guide are presented sequentially, in practice many associated tasks are concurrent and highly iterative, and have interactive dependencies that lead to alteration of previously established technical requirements.

This Guide specifies the 33 Sub-processes as shown in Figure 4b.

SUPPLY SUB-PROCESSES
1 – Product Supply

ACQUISITION SUB-PROCESSES
2 – Product Acquisition
3 – Supplier Performance

PLANNING SUB-PROCESSES
4 – Process Implementation Strategy
5 – Technical Effort Definition
6 – Schedule and Organization
7 – Technical Plans
8 – Work Directives

ASSESSMENT SUB-PROCESSES
9 – Progress Against Plans and Schedules
10 – Progress Against Requirements
11 – Technical Reviews

CONTROL SUB-PROCESSES
12 – Outcomes Management
13 – Information Dissemination

REQUIREMENTS DEFINITION SUB-PROCESSES
14 – Acquirer Requirements
15 – Other Stakeholder Requirements
16 – System Technical Requirements

SOLUTION DEFINITION SUB-PROCESSES
17 – Logical Solution Representations
18 – Physical Solution Representations
19 – Specified Requirements

IMPLEMENTATION SUB-PROCESSES
20 – Implementation

TRANSITION TO USE SUB-PROCESSES
21 – Transition to Use

SYSTEMS ANALYSIS SUB-PROCESSES
22 – Effectiveness Analysis
23 – Trade-off Analysis
24 – Risk Analysis

REQUIREMENTS VALIDATION SUB-PROCESSES
25 – Requirements Statements Validation
26 – Acquirer Requirements Validation
27 – Other Stakeholder Requirements Validation
28 – System Technical Requirements Validation
29 – Logical Solution Representations Validation

SYSTEM VERIFICATION SUB-PROCESSES
30 – Design Solution Verification
31 – End Product Verification
32 – Enabling Products Readiness

END PRODUCTS VALIDATION SUB-PROCESSES
33 – End Products Validation

Figure 4b – Sub-processes for engineering a system

The developer **should**: (1) decide which of the processes in Figure 4a apply to their enterprise; (2) decide which sub-processes from this Guide apply for the processes selected; (3) establish appropriate policies and procedures that govern project implementation; (4) define appropriate tasks for each of the selected sub-processes; and (5) establish methods and tools to support task implementation. Representative tasks, along with their expected outcomes, are provided in Appendix C for each sub-process of this Guide.

NOTES
1 The developer can be an enterprise, a group of enterprises, an organization or a project.
2 A developer can be either an acquirer or a supplier of systems, subsystems, or end products.
A developer can act in both roles (acquirer and supplier) simultaneously on the same project, e.g., supplying an end product to another organization, while acquiring subsystems from a third organization.

For a system that contains product elements for which lower-tier development standards exist, or where standards or guides exist for safety, security, or other system aspects, these **should** be used in conjunction with this Guide – for example: (1) IEEE/EIA 12207 for a system that contains software, or for a stand-alone software product; and (2) ANSI/EIA-649 for configuration management.

4.1 Acquisition and Supply

The Acquisition and Supply Processes are used by a developer to arrive at an agreement with another party to accomplish specific work and to deliver required products, or with another party or parties to have work done to obtain desired products. The parties can either be inside the developer's own enterprise (another project, functional organization, or project team), or can be in a different enterprise. The Acquisition and Supply Processes can be initiated as a result of a project go-ahead or approval decision, or by the receipt of an acquisition request, offer or directive. A project go-ahead can be given within an enterprise as a result of a market-needs analysis, technology breakthrough, a perceived market opportunity, a customer requirement, an internal project directive, or similar stimulus.

> NOTE – Although a project or development effort can be initiated by casual means, an agreement is nevertheless useful to ensure that all parties involved understand the purpose, goals, and expectations of the work.

An agreement can be between enterprises and between organizational elements within an enterprise, to include between projects, between projects and functional units, and between units within a project. The agreement within an enterprise can take the form of a work directive, work package, work authorization, or project memorandum of agreement. Agreements between enterprises can take the form of a formal contract for the delivery of a product, or a memorandum of agreement that establishes the working relationship between two or more enterprises on a common project.

Regardless of the form or purpose of the agreement, certain information **should** be included, for example:

a) Work to be performed;

b) Cost and schedule constraints;

c) Concept of operations;

d) Requirements to be satisfied, including known functional, performance, and interface requirements, attributes, and characteristics;

e) Product and data to be delivered;

f) Information pertaining to the cost, schedule, planning, delivery information, training and user manual, product structure, packaging and handling instructions, or installation instructions;

g) Appropriate technical plans;

h) Applicable financial structure, management and authority provisions;

i) Exit criteria for relevant enterprise-based life-cycle phases;

j) Identification of applicable engineering life-cycle phases;

k) Required technical reviews.

> NOTE – a developer can be developing a product with out any contractual relationship to the user or customer (e.g., commercial product development). However, much of the information above must be available to the developing organization in order to proceed.

The role of the developer with respect to the two processes of Acquisition and Supply is shown in Figure 4.1.

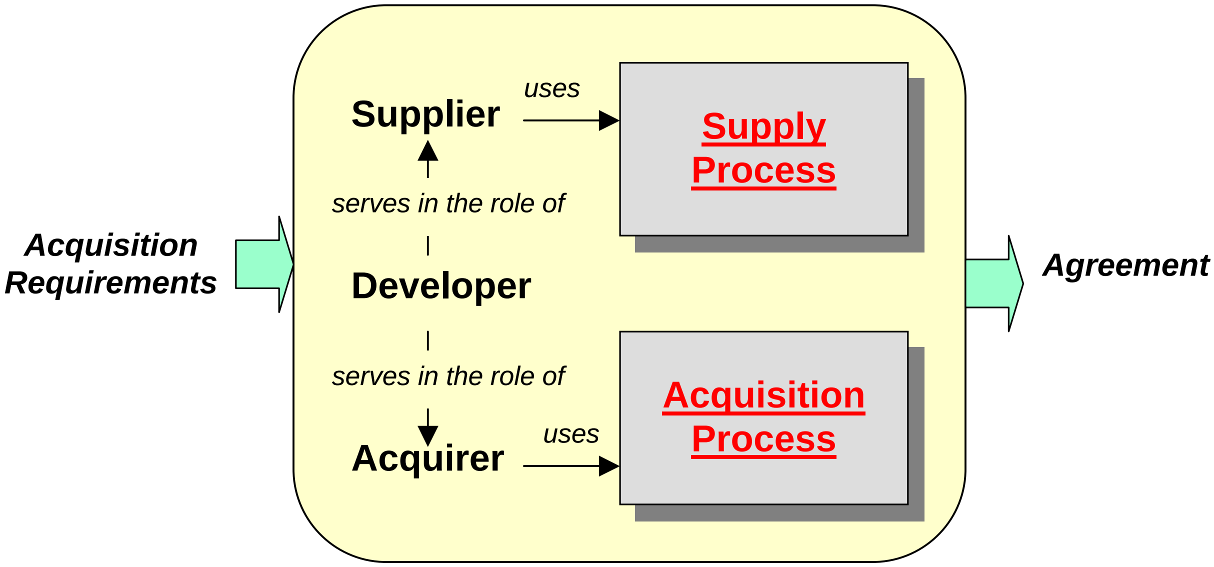


Figure 4.1 – Acquisition and Supply Processes

NOTES
1 The acquirer can be either one of the following:
   a. Internal to enterprise – for example, another project, marketing organization, parent project of a product team, the project team itself, executive manager, supervisor.
   b. External to enterprise – for example, procurement agency, prime contractor, another developer, buyer, customer, end user, owner, purchaser.
2 The supplier can be either one of the following:
   a. Internal to enterprise – for example, another project, functional organization, product team.
   b. External to enterprise – for example, another developer, prime contractor, producer, seller, subcontractor, vendor.

The sub-processes of this Guide apply to the developer in its role as acquirer, supplier, or both.

4.1.1 Supply Process

This process is used by the developer when acting as a supplier to establish and satisfy an agreement with the acquirer.

Sub-process 1 – Product Supply

For a system, or portion thereof, supplied to an acquirer, the developer (when acting as the supplier) **shall** establish and satisfy an agreement with the acquirer.

The supplier is typically thought of as a Prime Contractor, but may be a team within DoN or another government activity.

Preceding Process
Acquisition Process
   Sub-process 2: Product Acquisition
Planning Process
   Sub-process 8: Work Directives

Inputs

- Acquisition Strategy (SP 2)
- Solicitation (RFP, SOW or SOO with Cost/Schedule Requirements) (SP 2)
- Acquirer Offer (SP 2)
- Requests for clarification (SP 2)
- Request for Information (RFI) (SP 2)
- Acquirer Signed Agreement (contract or program directive) (SP 2)

NAVAIR Specific:

- Team Assignment Agreement (TAA) (SP 8)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents.

Tasks

The developer (as supplier) **should** plan and do appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Assess the acquisition request, offer, or directive to determine the capability to meet the acquisition document requirements**. Supplier develops business strategy and surveys marketplace for business opportunities (Commerce Business Daily (CBD)/Federal Business Opportunities (FedBizOpps/FBO) announcements/Sources Sought, etc.). Supplier obtains Request for Proposal/Quotation and allocates resources to review Request for Proposal/Quotation. For larger procurements the supplier would put together a team of personnel from various disciplines such as engineering, financial, logistics, and management. For some efforts, a field activity may be used – in the case of NAVAIR, a Naval Air Systems Command, Team Assignment Agreement (TAA) would be used. In the event another military service is used, a MIPR (Military Interservice Procurement Request) would be used. The team would review the RFP, determine what the requirements are, and then come up with their solution to meet all the requirements of the proposal. Some of the items that may be included in their proposal would include:

   - executive overview
   - technical approach
   - systems engineering
   - producibility
   - cost
   - schedule
   - performance
   - specifications
   - training
   - program management
   - support equipment (common and peculiar)
   - technology risks
   - human systems integration
   - packaging and handling
   - technical data
   - configuration management approach
   - work breakdown structure
   - site activation
   - industrial facilities
   - initial spares and initial repair parts

b) **Establish a satisfactory agreement within legal, regulatory, enterprise, and project bounds**. Supplier determines if the capability to meet the acquisition requirements exists, allocates resources needed to prepare the proposal/quotation, prepares proposal/quotation, submits (or presents orally) proposal/quotation, responds to proposal/quotation clarification questions from acquirer, and modifies

proposal in response to acquirer requests. The established agreement would also delineate any subcontracting that the prime contractor may enter into and any flowdown requirements.

c) **Record the established agreement in the form appropriate to the effort**. Supplier and acquirer negotiate contract terms. Supplier may have to prepare Best and Final Offer.

d) **Implement the processes of this Guide, as applicable, to meet the requirements of the agreement** (contract performance). Supplier and acquirer sign contract.

e) **Deliver the products and other deliverables as specified in the established agreement**. Supplier performs work required by the contract, while acquirer monitors supplier's performance and compliance with requirements. Supplier develops and documents the final product design. Supplier manufactures and tests product. Supplier develops required product documentation and other technical data as delineated in the Supplier Signed Agreement.

Outputs

All outputs should be archived (SP 12)

- Supplier Proposal (SP 2)
- Supplier Signed Agreement (contract or program directive) (SP 2)
- End Products (SP 2, 3, 20, 31, 33)
- Enabling Products (SP 2, 3, 20, 31, 32, 33)

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents. (Products/Deliverables meet Agreement Requirements)

Next Processes

Acquisition Process
    Sub-process 2: Product Acquisition
Control Process
    Sub-process 12: Outcomes Management
Implementation Process
    Sub-process 20: Implementation
System Verification Process
    Sub-process 31: End Product Verification
    Sub-process 32: Enabling Products Readiness
End Products Validation Process
    Sub-process 33: End Products Validation

Agents

Contracts
Systems Engineering
Logistics/R&M
Business Development
Acquirer
Manufacturing
Technical Writer
Legal
Security

Tools

Requirements Management & System Architecture Database (ex. CORE™, DOORS, SLATE™)
Make versus Buy
PRWeb

References

Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

MIL-STD-961
MIL-HDBK-245
SD-2 Buying Commercial and Non-Developmental Items: A Handbook
SD-5 Market Research
OSD Commercial Item Acquisition: Considerations and Lessons Learned, 26 June 2000
Managing Quality and Productivity in Aerospace and Defense, November 1989

NAVAIR Specific:

- **NAVAIRINST 5400.154**

Metrics and Measures

- Timeliness of the supplier against the completion of the contract, task orders, milestones, delivery schedules, administrative requirements, etc.
- Compliance with technical performance requirements.
- Effectiveness in forecasting, managing, and controlling contract cost.
- Management Responsiveness – Timeliness, completeness, and quality of problem identification, corrective action plans, proposal submittals (especially responses to change orders, engineering change proposals, or other undefinitized contract actions), the contractor's history of reasonable and cooperative behavior, effective business relations, and customer satisfaction.
- Subcontract Management - timeliness of award and management of subcontracts, including whether the contractor met small/small disadvantaged and women-owned business participation goals.
- Program Management and Other Management - Assess the extent to which the supplier discharges their responsibility for integration and coordination of all activities needed to execute the contract; identifies and applies resources required to meet schedule requirements; assigns responsibility for tasks/actions required by the contract; and communicates appropriate information to affected program elements in a timely manner. Assess the supplier's risk management practices, especially the ability to identify risks and formulate and implement risk mitigation plans. If applicable, identify and assess any other areas that are unique to the contract, or that cannot be captured elsewhere under the Management element.
- Number and severity of discrepancies documented during product verification.
- Number and severity of unresolved discrepancies.
- Acceptance of test results.

The expected outcomes for these representative tasks are provided in Appendix C, Table C.1. The outcomes associated with completing this sub-process influence the Acquisition, Planning, and Control Processes and will flow to all areas.

4.1.2 Acquisition Process

The developer when acting as an acquirer to establish an agreement with a supplier and to manage supplier performance uses this process.

The Acquisition Process includes the two sub-processes shown in Figure 4.1.2.

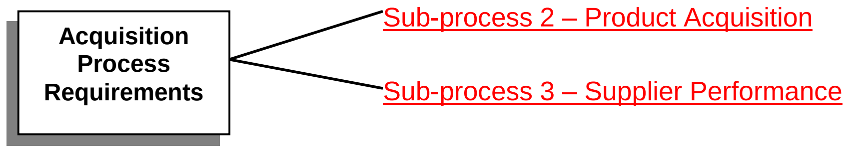


Figure 4.1.2 – Acquisition Process/Sub-processes

Sub-process 2 – Product Acquisition

For a system, or portion thereof, acquired from a supplier, the developer (when acting as the acquirer) **shall** establish an agreement with that supplier.

The supplier is typically thought of as a Prime Contractor, but may be a team within DoN or another government activity. The acquisition may be competitive or sole source. There are different procedures, which must be followed depending on whether the acquisition is competitive or sole source.

For major weapon systems, the acquisition process initiates within the service or field commander-in-chief's ongoing mission area need analysis effort, which may result in an Initial Capabilities Document (ICD) – formerly Mission Need Statement (MNS). By certifying a mission need, the ICD may result in a Concept Decision to explore material solutions. The program then enters the Concept Refinement Phase, during which system alternatives are explored. The next phase occurs after Milestone A, and is known as Technology Development (formerly Component Advanced Development (CAD)). The preferred system concept is defined by a set of system performance requirements, and the technology is demonstrated to show that any significant technical and acquisition risk areas identified have been brought under sufficient control to warrant entering the next program phase. Program Initiation begins at Milestone B, which is the beginning of the System Development and Demonstration (SDD) (formerly EMD) Phase. The SDD Phase includes the System Integration and the System Demonstration Work Efforts, which are separated by the programmatic Design Readiness Review, and the product Critical Design Review (CDR). The preliminary design and detailed designs are completed during the System Integration Work Effort, and tests are performed during the System Demonstration Work Effort.

Following the Milestone C, the system enters the Production and Deployment phase, during which low-rate initial production and full-rate production takes place. After Initial Operating Capability (IOC) occurs, the Operations and Support phase is entered, modifications and product improvements are usually implemented. At the end of the system service life it is disposed of in accordance with applicable classified and environmental laws, instructions, regulations, and directives. Disposal activities also include recycling, material recovery, salvage reuse, and disposal of by-products from development and production.

At the conclusion of the first three phases, the requirement for the program is re-certified by the Milestone Decision Authority (MDA) before additional resources are authorized. At each review, the decision authority may also direct a tailored program to omit or combine specific phases. These special cases are normally based on the decision authority being convinced that the technology and design maturity support such a decision. (For additional information see the Defense Acquisition University, *Systems Engineering Fundamentals*, Dec 2000, Defense Acquisition University Press).

Preceding Process

Supply Process
- Sub-process 1: Product Supply

Acquisition Process
- Sub-process 3: Supplier Performance

Planning Process
- Sub-process 5: Technical Effort Definition

Sub-process 6: Schedule and Organization
Sub-process 7: Technical Plans
Sub-process 8: Work Directives
Requirements Definition Process
Sub-process 14: Acquirer Requirements
Solution Definition Process
Sub-process 19: Specified Requirements
End Products Validation Process
Sub-process 33: End Products Validation

Inputs *("EXT" indicates it is external, unspecified, and not from a sub-process.)*

- Supplier Proposal (SP 1)
- Supplier Signed Agreement (contract or program directive) (SP 1)
- End Products (SP 1)
- Enabling Products (SP 1)
- Supplier Performance Management Plan (SP 3)
- Work Breakdown Structure (WBS) (SP 5)
- Integrated Master Schedule (IMS) (SP 6)
- Test and Evaluation Management Plan (TEMP) (SP 7)
- Source Selection Plan (SSP) (SP 7)
- Team Work Plan (TWP) (SP 8)
- Statement of Objectives (SOO) (SP 8)
- Statement of Work (SOW) (SP 8)
- Initial Capabilities Document (ICD) – formerly Mission Needs Statement (MNS) (SP 14)
- Capability Development Document (CDD) or Capability Production Document (CPD) – formerly Operational Requirements Document (ORD) (SP 14)
- Specified Requirements (SP 19)
- Operational Test Readiness Review (OTRR) certification message (SP 33)
- Cost, Schedule, and Performance constraints (EXT)
- Acquisition Strategy (EXT)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents.

Tasks
The developer (as acquirer) **should** plan and do the appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Prepare the applicable acquisition request, offer, or directive to obtain supply of work or delivery of desired system products**.

1) The contracting process begins with planning efforts. Planning includes development of a Request for Proposal (RFP), specifications (**Sub-process 19**), a Statement of Work (SOW) or Statement of Objectives (SOO), a Source Selection Plan (SSP), and the Contract Data Requirements List (CDRL). The SOW is a statement of the work to be done. A SOO can be utilized to obtain a SOW or equivalent during the selection process.
2) The RFP is the solicitation for proposals. The government distributes it to potential contractors. The RFP delineates the need and what the offeror must do to be considered for the contract. It establishes the basis for the contract that will be put in place.
3) The information required to be in the proposals responding to the solicitation is also key for the systems engineer. The engineering team decides the technical and technical management merits of the proposals. The directions to the offerors must be clearly and correctly stated, otherwise the proposal will not contain the information needed to evaluate the offerors.
4) The acquisition package contains the documents that will be provided to the offerors as part of the RFP. The RFP normally includes:

- Contract Data Requirements List (DD Form 1423)
- Contract Schedule, Specification
- SOW (Statement of Work) or SOO (Statement of Objectives)
- Proposal Requirements
- Contract Security Classification (DD Form 254)
- Supplier Performance Management Plan (optional but recommended)

There are other documents that are part of the Acquisition Package, which are kept internal to the Government and must remain as part of the contract file. These documents typically include:

- Procurement Request
- Funding Authorization Document
- Procurement Planning Schedule
- Source List
- Proposal Evaluation Plan

A description of the various types of acquisition packages and their content may be found at **http://www.ntsc.navy.mil/Resources/Library/Acqguide/Acqguide.htm**

Another source for information is available at the Navy's Acquisition Reform web site http://www.acq-ref.navy.mil/index.html

b) **Evaluate supplier response to acquisition request, offer, or directive**. The process begins with the development of a Source Selection Plan (SSP), which relates the organizational and management structure, the evaluation factors, and the method of evaluating the offerors' responses. The evaluation factors and their priority are transformed into information provided to the offerors in sections L and M of the RFP. The offeror's proposals are then evaluated with the procedures delineated in the SSP. These evaluations establish which offerors are conforming, guide negotiations, and are the major factor in contractor selection. The system engineering area of responsibility includes support of SSP (Source Selection Plan) development by preparing the technical and technical management parts of evaluation factors; organizing technical evaluation teams; and developing methods to evaluate the offeror's proposals (technical and technical management).

Source selection determines which offeror will be the contractor, so this decision will have profound impact on program risk. The systems engineer should approach the source selection with great care since, unlike many planning decisions made early in product life cycles, the decisions made relative to source selection can generally not be easily changed once the process begins. Laws, regulations, directives, and instructions governing the fairness of the process require that changes be made very carefully, and frequently at the expense of considerable time and effort on the part of program management and contractor personnel. In today's environment, even minor mistakes can cause distortion of proper selection. Because of the importance of this process NAVAIR has a source selection office (AIR-4.10E) chartered with the responsibility to ensure the source selection process is properly executed.

c) **Make offer or provide directive to desired supplier**. After the source selection is completed, an offer is made or directive provided to the selected contractor(s).

d) **Negotiate agreement to establish a satisfactory agreement within legal, regulatory, enterprise, and project bounds**. A satisfactory agreement is established based on the bounds determined by, as appropriate:

1) applicable legal, regulatory, policies, procedures, directives, instructions and practices that will affect negotiation strategy;
2) the type of agreement to be negotiated;
3) negotiation strategy;

4) conditions identified from the plans for the procurement work effort that could affect negotiations and agreement performance; and
5) constraints identified from the plans for the procurement work effort that could affect negotiations and agreement performance.

e) Record the established agreement in the form appropriate to the effort (goes to **Sub-process 12**). Upon completion of the source selection process, and after any negotiations are finished, a contract is prepared and sent to the contractor(s) for signature. After the contractor signs, the contract is returned to the PCO (Procurement Contracting Officer) for signature on behalf of the government. Once the contract has been signed by the contractor and government, its terms and conditions are enforceable by law.

f) Accept delivered products. Installed or delivered system products must be validated as satisfying user, customer, or assigned requirements, and meeting other applicable certification or acceptance criteria. A DD Form 250 is frequently used to accept deliveries on behalf of the government.

Outputs

All outputs should be archived (SP 12)

- Cost, schedule, and performance constraints (SP 5, 8)
- Acquisition Strategy (SP 1, 5, 6)
- Solicitation (RFP, SOW or SOO with Cost/Schedule Requirements) (SP 1, 3, 5)
- Acquirer Offer (SP 1)
- Request for Clarification (SP 1)
- Request for Information (RFI) (SP 1)
- Acquirer Signed Agreement (contract or program directive) (SP 1)
- ILS Certification (SP 21)
- Signed DD Form 250(s) (SP 21)

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents. (Products/Deliverables meet Agreement Requirements)

Next Processes

Supply Process
  Sub-process 1: Product Supply
Acquisition Process
  Sub-process 3: Supplier Performance
Planning Process
  Sub-process 5: Technical Effort Definition
  Sub-process 6: Schedule and Organization
  Sub-process 8: Work Directives
Control Process
  Sub-process 12: Outcomes Management
Transition to Use Process
  Sub-process 21: Transition to Use

Agents

Contracts
Source Selection
Legal
Program Manager (PM)
System Engineering
Logistics
T&E

Tools

Specifications
PRWeb
Proposal Evaluation Report
Turbo Streamliner
Turbo Specright!

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

MIL-STD-961D
MIL-HDBK-245
MIL-STD-499B
SD-2 Buying Commercial and Non-Developmental Items: A Handbook
SD-5 Market Research
Capability Maturity Model®Integration (CMMI℠), 2001: Supplier Agreement Management and Integrated Supplier Management process areas
OSD Commercial Item Acquisition: Considerations and Lessons Learned, 26 June 2000
Managing Quality and Productivity in Aerospace and Defense, November 1989
DD Form 1423
DD Form 254
DD Form 250

Metrics and Measures
Metrics are measurements collected for the purpose of ascertaining project progress and overall condition by observing the change of the measured quantity over time. Measurement, evaluation and control of metrics are normally attained through a system of periodic reporting that must be planned, established, and monitored to assure metrics are properly measured, evaluated, and the resulting data disseminated.

IPT Participation, Review and Concurrence – The IPT should be involved from program initiation and during reviews - there should be a consensus from the IPT at each step along the way.

Technical Reviews – typical system-level technical reviews (described in Sub-process 11) -

- Alternative System Review
- System Requirements Review
- System Functional Review
- Preliminary Design Review (Includes System Software Specification Review)
- Critical Design Review
- Test Readiness Review
- Production Readiness Review
- System Verification Review
- Functional Configuration Audit
- Physical Configuration Audit/Review

Product Metrics – track key attributes of the design to examine progress toward meeting customer requirements.

Product metrics reflect three basic types of requirements:

- Operational Performance
- Life-cycle Suitability

- Affordability

Measures of Effectiveness (MOEs): Metrics used to measure results achieved in overall mission and execution of tasks. MOEs are a prerequisite to the performance of combat measurement (CJCSI 3170.01C).

Measures of Performance (MOPs) – measures a system's technical performance expressed as speed, payload, range, time on station, frequency, or the distinctly quantifiable performance features. Several MOPs may be releated to the achievement of a particular MOE.

Technical Performance Measurements (TPM) – derived directly from MOPs and are selected as being critical from a periodic review and control perspective.

Suitability Metrics – tracking metrics relating to operational suitability, and other life cycle concerns may be appropriate to monitor progress toward an integrated design. Operational suitability is the degree to which a system can be placed satisfactorily in field use considering availability, compatibility, interoperability, transportability, human factors, reliability, maintainability, documentation, safety, training, manpower, supportability, logistics, usage rates, and environmental impacts.

Product Affordability – estimated unit production cost can be tracked during the design effort in a manner similar to the TPM approach, with each CI (Configuration Item) element reporting an estimate based on current design.

Timing – product metrics are tied directly to the design process. Planning for metric identification, reporting, and analysis is started with initial planning in the concept exploration phase.

Earned Value – reporting system that uses cost-performance metrics to track the cost and schedule progress of system development against a projected baseline. It's a "big picture approach" and integrates concerns related to performance, cost and schedule.

Process Metrics – management process metrics are measurements taken to track the process of developing, building, and introducing the system.

The expected outcomes for these representative tasks are provided in Appendix C. The outcomes associated with completing this sub-process influence the Supply, Planning, and Control Processes.

Sub-process 3 – Supplier Performance

The developer (when acting as the acquirer) **shall** manage supplier performance (and sub-suppliers) to ensure that the technical effort to be accomplished by the supplier provides end products that satisfy the assigned requirements.

The focus of this task is to Manage Supplier Performance by monitoring the supplier against key product and process metrics that can include periodic reviews (i.e., incoming and final inspection, facility capability audits, and process capability studies). Sub-process 3 is invoked whenever subsystem products are acquired from suppliers or lower-tier developers outside the enterprise, as well as when the supplier is an organizational entity within the developer's own enterprise.

Preceding Process

Supply Process

Sub-process 1: Product Supply

Acquisition Process

Sub-process 2: Product Acquisition

Assessment Process

Sub-process 9: Progress Against Plans and Schedules

Sub-process 10: Progress Against Requirements
Control Process
Sub-process 13: Information Dissemination
Solution Definition Process
Sub-process 19: Specified Requirements

Inputs

- Solicitation (RFP, SOW or SOO with Cost/Schedule Requirements) (SP 2)
- Specified Requirements (SP 19)
- Acquirer Signed Agreement (contract or program directive) (SP 2)
- Approved changes (SP 13)
- End Products (SP 1)
- Enabling Products (SP 1)
- Plans and schedules trend analysis (SP 9)
- Requirements trend analysis (SP 10)

Entry Criteria

Inputs have been approved by the appropriate agents

- Sponsor/User Agreement
- Negotiated Agreement
- Validated Requirements

Tasks

The developer (as acquirer) **should** plan and do appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Define the required developer-supplier relationships**. This should include discussions concerning all work and products to be delivered against the technical requirements. This should include audits and review of the processes. This should include a Supplier Performance Management Plan to be sent to **Sub-process 2** for inclusion in a negotiated agreement.

b) **Participate on appropriate supplier product teams**. The effort should include periodic meetings to verify and document that the supplier has a correct and complete understanding of the requirements and processes in place to satisfy them.

c) **Monitor supplier performance against key product metrics**. A detailed list of all Key Product Metrics (from **Sub-process 10** – Progress Against Requirements) should be provided to the Supplier and monitored by the Acquirer.

d) **Flow-down changes in requirements or operational concept that might affect the supplier's project**. An accurate Configuration Management (CM) program should be established to track all requirements and changes to those requirements and that they are flowed down to the contractors and sub-contractors.

e) **Control changes to requirements made by the supplier that would affect the developer's project or other related projects or products**. Any changes made by the supplier should be verified against the requirements before approval of such changes. Flow down and control changes through an active Configuration Management program and report to **Sub-process 12** – Outcomes Management).

f) **Assess supplier performance against assigned requirements including conduct of, or participation in, appropriate technical reviews**. The acquirer and supplier should mutually agree on the format of the technical reviews and how to resolve misunderstandings, oversites, and errors (**Sub-process 10** – Progress Against Requirements).

g) **Validate products delivered from the supplier, or ensure that products have been validated before delivery and prior to integration with other products that form a composite end product**

intended to meet the developer's specified requirements. This is a critical requirement which requires validation of all work and products delivered as early in the process as practical, to ensure that they are ready when needed for product integration and/or for Enabling Products. Validate all work and products delivered (**Sub-processes 32** and **Sub-process 33**) and report to **Sub-process 29** – Logical Solution Representations Validation).

Outputs *(List of sub-processes where output is used may include the originating sub-process.)*
All outputs should be archived (SP 12)

- Supplier Performance Management Plan (SP 2, 3)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents.

- All Key Product Metrics have been successfully accomplished
- All Technical Reviews have been completed
- Delivered Products satisfy requirements and approved changes.

Next Processes
Acquisition Process
  Sub-process 2: Product Acquisition
Control Process
  Sub-process 12: Outcomes Management

Agents

- Acquirer/Developer
- Program Executive Officer (PEO) / Program Manager (PM)
- User/Fleet
- Logistics
- Procurement
- Systems Engineering

Tools

- Requirements Management & System Architecture Database (ex. CORE™, DOORS, SLATE™)
- Project Management Tools (ex. Microsoft Project)
- Tools Survey: Requirements Management Tools

References
Standard across all systems engineering efforts:

  - **DoD 5000 Series**
  - **AT&L Knowledge Sharing System (AKSS)**
  - **FAR/DFARs**
  - **Defense Acquisition University: Systems Engineering Fundamentals**
  - **INCOSE Systems Engineering Handbook**
  - **C4ISR Architecture Framework**
  - **Joint Technical Architecture**

Capability Maturity Model® Integration (CMMI℠), 2001: Supplier Agreement Management process areas

Metrics and Measures

- Report supplier progress against Key Product Metrics
- Report percentage of Flow Down requirements changes (CM)
- Report on percentage of products delivered that have been validated and need to be validated.

The expected outcomes for these representative tasks are provided in Appendix C. The outcomes associated with completing this sub-process influence the Planning, Assessment, Control, and Implementation Processes.

4.2 Technical Management

The Technical Management Processes are to be used to plan, assess, and control the technical work efforts required to satisfy the established agreement. The relationship of the three Technical Management Processes for planning, assessing, and controlling the technical effort is shown in Figure 4.2

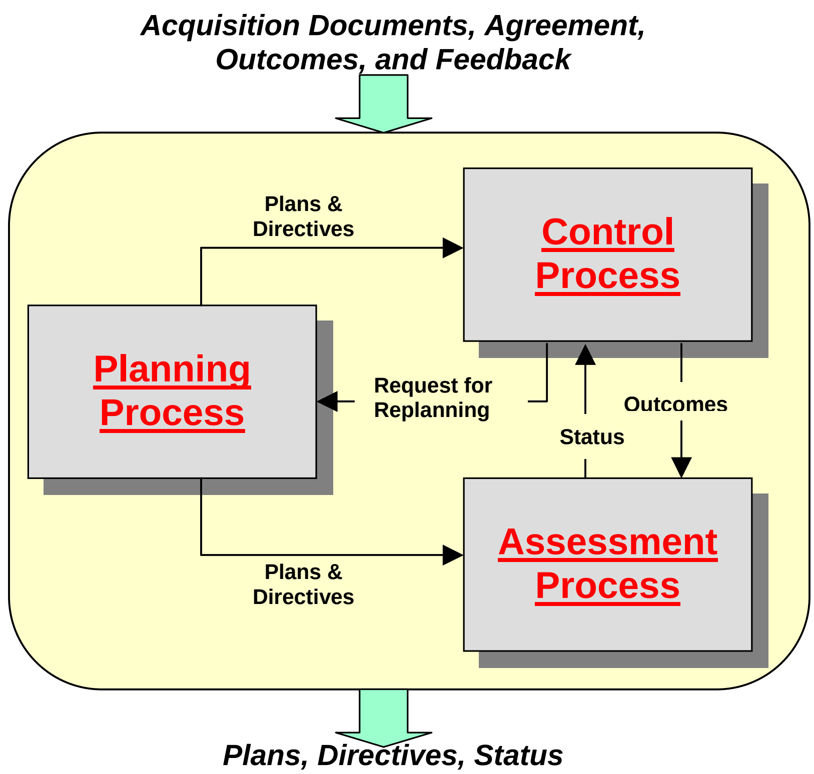


Figure 4.2 – Technical Management Processes

NOTES 1 The acquirer can be either one of the following: a) Internal to the enterprise – for example, another project, marketing organization, parent project of a product team itself, executive manager, supervisor. b) External to the enterprise – for example, procurement agency, prime contractor, another developer, buyer, customer, end user, owner, purchaser. 2 The supplier can be either one of the following: a) Internal to the enterprise – for example, another project, functional organization, product team. b) External to the enterprise – for example, another developer, prime contractor, producer, seller, subcontractor, vendor. 3 The sub-processes of this Guide apply to the developer in its role as acquirer, supplier, or both.

4.2.1 Planning Process

This process is used to support enterprise and project decision making and to prepare necessary technical plans that support and complement project plans to: (1) arrive at a decision to supply services according to an external solicitation; (2) determine whether to proceed with an internal enterprise project for a new product or a product improvement; (3) guide the work efforts that will meet the requirements of an established agreement; or (4) replan applicable processes for engineering a system. Replanning is normally initiated (1) when required by an

agreement; (2) when significant variations or anomalies are identified from other Technical Management process outcomes; or (3) before implementation of the next enterprise-based life-cycle phase.

The five sub-processes associated with the Planning Process are shown in Figure 4.2.1a.

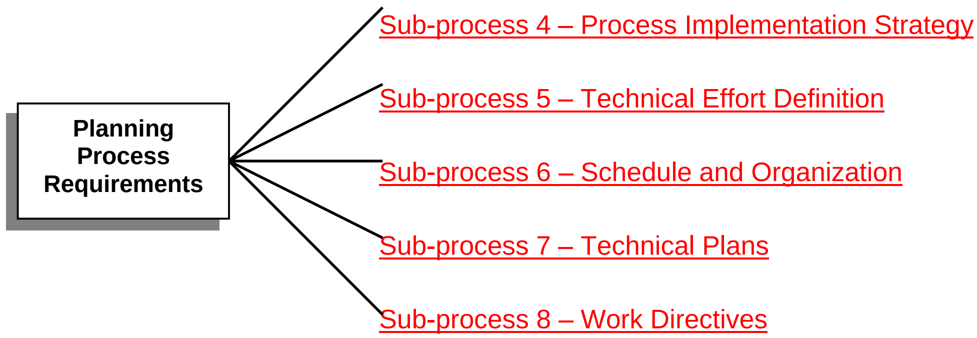


Figure 4.2.1a – Planning Process/Sub-processes

Sub-process 4 – Process Implementation Strategy

The developer **shall** define a strategy for implementing the adopted process of this Guide as a basis for project technical planning and that is in accordance with the agreement.

The intent is to provide enough information for the user to determine whether a given process activity is appropriate in supporting the objectives of the program or project they support and how to go about implementing the process activity.

Note that the act of planning should not be carried out in a vacuum. It is iterative and thus will require inputs regarding the Technical Effort, Schedule, Technical Plans, and Work Directives.

Preceding Process
Requirements Definition Process
    Sub-process 14: Acquirer Requirements

Inputs
Capability Development Document (CDD) or Capability Production Document (CPD) – formerly Operational Requirements Document (ORD) (SP 14)
Initial Capabilities Document (ICD) – formerly Mission Needs Statement (MNS) (SP 14)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agent.

This is where it all starts. When someone asks the simple question, “What’s your plan?” or “How are you going to get it done?”, this sub-process is initiated and the whole systems engineering process is begun. It is reentered when things change significantly, such as funding, requirements, or schedule.

This process must start at the very beginning of a Major Acquisition at Milestone A and be reviewed at each subsequent Milestone B, C, and IOC. An example of when you may reenter this process would be when a Key Performance Parameter (KPP) is not going to be met, requirements change, or drastic policy/funding/schedule changes.

For less formal projects, the entry criteria can simply be a request from a Program Manager for Systems Engineering resources.

Tasks

The developer **should** plan and do appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Identify stakeholders who will have an interest or stake in the outcome of the projec**t. Consider stakeholders in both the Funding Chain and Beneficiary Chain (other stakeholders, primary users, etc.).

b) **Identify and acquire applicable documents and the requirements therein, that could affect the project**. This will ensure the current and accurate documentation of the Engineering Baseline. The Systems Engineer is responsible for the implementation of, and adherence to, approved policies and processes. (For NAVAIR, reference the Class Desk Orientation: Roles & Responsibities presentation.) Making the applicable documents available in a project library enables the project's personnel to easily access the same baselined information as they perform their work. At a minimum, list the document name, version, and date for historical purposes. This information should be stored in the Enterprise Data Repository established in **Sub-process 5**.

c) **Identify process approaches required to develop enabling products that serve as the roadmap for program execution from program initiation through post-production support**. The essential elements to include in the process, but not to be limited to, are risk management, training, testing, modeling and simulation, open systems, cost as an independent variable, environment considerations, and source of support

d) **Identify applicable enterprise-based life-cycle phases (see Appendix B), expected work product outputs, applicable management reviews, and life-cycle-phase exit criteria**. This SE Guide is defining the DoN SE activities that satisfy the DoD 5000 requirements.

e) **Identify and define how the applicable processes of this Guide will be integrated, how internal and external projects will be involved, and how they will be integrated**.

   1) Read all of this document to get the overall interrelationship of the processes and the document's philosophy and approach.

   2) Take into account the phase and scope of your program using the available documents and DoD 5000, if required. Do this early in a program, since fewer guiding documents will be available later in the program.

   3) Identify an initial list of which inputs and outputs are required to execute the program.

   4) Tracing the inputs and outputs through sub-processes will reveal a number of things:

      a. Determine the level of process applicability and tailoring required.

      b. Additional inputs required.

      c. Support resources required and where these resources are available.

   5) Check to see what outputs are produced by each process to see if all apply to the program considering its phase and scope. The descriptive portion of the tasks of a sub-process contains clarifications of these outputs. This portion also gives guidance on developing the output by identifying the tools and organizations that are involved, and detailing some interrelationships between the organizations.

   6) Create a tailored version of this systems engineering process for your project. Creating a top-level plan can be accomplished by developing a Gantt chart using the schedule and tasking information

in the Inputs and the tailored process list. Consult with those responsible for the Technical Effort, Schedule, Technical Plans, and Work Directives to determine how the details will be filled in.

f) **Identify and define progress assessment metrics and reporting requirements**. The frequency and format of progress reports will impact the effort calculations in **Sub-process 5** and the establishment of schedules in **Sub-process 6**. The decision whether or not to use an Earned Value Management System will also have impacts in Sub-processes 5 and 6.

   Select meaningful Metrics and Measures specific to the program and add them to the generic list. Acknowledge that someone else is responsible for executing the process. That person will be responsible for defining and collecting metrics for both the process itself and the products that are produced. Without measuring the process itself, there is no way to tell that a change to the process was actually an improvement.

g) **Prepare, document, and make available the process implementation strategy**. This documentation should also include details for modifications to the process implementation strategy.

Outputs *(List of sub-processes where output is used may include the originating sub-process.)*
All outputs should be archived (SP 12)

- List of stakeholders and roles (SP 4, 15)
- Associated process approaches (SP 4)
- Life-cycle phase chart (Milestones) (SP 4, 6, 8)
- Work products and outputs (SP 4) – (e.g., Work Breakdown Structure (WBS))
- Work product reviews (SP 4)
- Life-cycle phase exit criteria (SP 4, 8)
- List of applicable tasks (SP 4)
- Program metrics and reporting requirements (SP 4)
- Project Library (SP 5)
- Process Implementation Strategy (SP 5, 6, 7, 8)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agent.
Planning team agrees to estimates and customers acknowledge receipt of information.

Next Processes
Planning Process
  Sub-process 5: Technical Effort Definition
  Sub-process 6: Schedule and Organization
  Sub-process 7: Technical Plans
  Sub-process 8: Work Directives
Control Process
  Sub-process 12: Outcomes Management
Requirements Definition Process
  Sub-process 15: Other Stakeholder Requirements

Agents
Systems Engineering
Program Manager
Logistics

Suggested Tools
Master Acquisition Planning Program (MAPP) v1.1

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

Capability Maturity Model®Integration (CMMI[SM]), 2001: Integrated Project Management process areas

NAVAIR Specific:
- Class Desk Orientation Presentation, March 2000
- **NAVAIR Acquisition Guide, January 2004**
- **NAVAIRINST 4200.36C, Acquisition Plans, 2004**

Metrics and Measures
Estimated cost of project
Estimated schedule of project
Estimated cost and time spent planning
Actual cost and time spent planning

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process: (1) provide a roadmap for the technical implementation of the project, including engineering life-cycle activities within specified enterprise-based life-cycle phases; (2) are to be inplementable by each product team or product manager; (3) are used in preparing and negotiating an agreement; and (4) influence the developer's ability to fulfill other requirements of the Planning Process.

The process implementation strategy includes requirements for the processes to be undertaken, applicable constraints, completion criteria, and feasibility of each process, considering resources (personnel, materials, and technology) and the project execution environment. This strategy can be a part of the project plan or a stand-alone document.

Sub-process 5 – Technical Effort Definition

The developer **shall** define a technical effort that is in accordance with the process implementation strategy.

Preceding Process
Acquisition Process
    Sub-process 2: Product Acquisition
Planning Process
    Sub-process 4: Process Implementation Strategy
    Sub-process 6: Schedule and Organization
    Sub-process 7: Technical Plans
Requirements Definition Process
    Sub-process 14: Acquirer Requirements
    Sub-process 15: Other Stakeholder Requirements
    Sub-process 16: System Technical Requirements

Inputs
- Process Implementation Strategy (SP 4)
- Project Library (SP 4)
- Organizational Structure (SP 6)
- Integrated Master Schedule (IMS) (SP 6)
- Program Operating Guide (POG) (SP 6)

- Acquirer requirements (SP 14)
- Measures of Effectiveness (MOEs) (SP 14)
- Other stakeholder requirements (SP 15)
- System technical requirements (SP 16)
- Data and Document Management Plans (SP 7)
- Configuration Management Plans (SP 7)
- Acquisition Strategy (SP 2)
- Cost, schedule, and performance constraints (SP 2)
- Solicitation (RFP, SOW or SOO with Cost/Schedule Requirements) (SP 2)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agent.

Tasks
The developer **should** plan and do appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Identify project tasks to include all requirements; and enterprise, project, and associated process constraints**. This sub-process will address what tasks an organization needs to do to define, control, and measure its work. It addresses the processes and not the products or the results of the work.

   Product definition, development, tests and logistics requirements are described elsewhere (sub-processes 14 through 19). The sub-process produces a description of the work to be done, resources, schedules, funding, and reporting requirements for competency support. (For NAVAIR, a Team Assignment Agreement accomplishes this task.) See **Sub-process 8** for further elaboration. The Contract defines the agreed requirements for contracted services. See **Sub-processes 1** and **Sub-process 2** for further elaboration.

   The ISO 9000 and ISO 14000 family of management system standards can be used as a supplemental source to help define the technical tasks. They are available at the following website: http://www.iso.ch/9000e/magical.htm. The management system standards in these families state requirements that the organization must implement to manage processes influencing quality (ISO 9000) or the processes influencing the impact of the organization's activities on the environment (ISO 14000). Both address the way an organization defines its work, and not directly the result of this work.

   A Technical Data Package (TDP) (reference: http://www.nalda.navy.mil/techdata) is a technical description of an item adequate for supporting an acquisition strategy, development, manufacturing development, production, engineering, and logistics throughout the item's life cycle. The TDP should be produced as part of the data that makes up the product requirements. This sub-process identifies the need for, and content of, the TDP. The data and documentation is produced by **Sub-process 7** and used by **Sub-process 12**. Acquisition programs must acquire the minimum essential data required to support the defense system life cycle. Timing of data delivery or access is critical to support affordable readiness.

   The categories of data that may be included in a TDP, but not limited to, are:
   - Product Definition Data: This denotes the totality of data elements required to completely define a product. Product definition data includes geometry, topology, relationships, tolerances, attributes, and features necessary to completely define a component part or an assembly of parts for the purpose of design, analysis, manufacture, test, and inspection.
   - Engineering Drawings: Engineering drawings disclose the physical and functional requirements of an item using graphic and/or textual presentations.
   - Associated Lists
   - Specifications
   - Standards
   - Performance Requirements

- Quality Assurance Provisions
- Reliability Data
- Packaging Details
- Modeling Data

A Technical Data Package (TDP) is beneficial in supporting:
- Program risk assessment and design management
- Evaluation and control of physical and functional design interrelationships of interdependent components, equipment, subsystems, or systems
- Configuration management and configuration control
- Re-procurement/Competition in Contracting Act
- Competitive procurement of the system or sub-system
- Competitive procurement of spares and repair parts
- Standardization
- Training personnel
- Installation and operation of items, equipment, subsystems, or systems
- Maintenance
- Overhaul, repair, and rework
- Inspection and quality control
- Cataloging and provisioning
- Logistics operations (i.e., demilitarization, investigations, etc.)
- Obsolescence replacement

b) **Establish an Enterprise Data Repository (including an information database)** that will allow capture of project data and be able to securely retain and make information available, as required. After this repository is established it is used by **Sub-process 12** to manage the outcomes of this process. In order to clarify the effort, a description follows:

Enterprise Data Repository. An information repository preserving all program pertinent information needed by any and all of the program stakeholders should be established and maintained. Information sharing mechanisms could include share folders, program libraries, formal and informal presentations, technical interchanges, e-mail, and web pages. Appropriate access and security requirements need to be defined and implemented. It should at least contain all contract relevant documents, program requirements, position papers, official communications, risks, action items, schedules and cost data. This repository is what is set up to be used by **Sub-process 12** for outcomes management

Common References. As a supplement to program specific information, databases and repositories of instructions, MIL STDs, and Industry Standards are also globally available. The program can use these to more thoroughly define its technical effort in a disciplined fashion and draw on a large documented source of expert information. Navy and Marine Corps Instructions including the Design Reviews Instruction can be found at the following website: **http://www.nalda.navy.mil/instructions/**. A list of some useful MIL-STDs can be found in **Appendix G**: Engineering Specialty References. An index of on-line standards available to IEEE subscribers is currently at the following website: **http://standards.ieee.org/catalog/olis/index.html**. A complete listing of published International Standards, classified by subject, is available at the following website: **http://www.iso.ch/**. The AT&L Knowledge Sharing Systems contains mandatory and discretionary policy documents including laws, directives, and regulations. It can be found at the following website: **http://deskbook.dau.mil/jsp/default.jsp**.

c) **Determine the risk management strategy** to identify technical risks to the appropriate level and to properly avert those risks that could adversely affect the project. Identify the effort required to define and control technical risks that need to be considered in developing a Risk Management strategy. **Sub-process 7** will address what needs to be done (planned) to implement the strategy and **Sub-process 24** discusses the risk analysis process. In order to define the effort, a definition follows:

Risk Management is the systematic approach to identifying, analyzing, and controlling areas or events with a potential for causing unwanted change. It is through risk management that risks to the program are assessed and systematically managed to reduce it to an acceptable level. Risk is a measure of the inability to achieve overall program objectives within defined cost, schedule, and technical constraints. It has two primary components: (1) the probability of failing to achieve a particular outcome and (2) the consequences of failing to achieve that outcome. Risk Management is the act or practice of controlling risk. The Risk management strategy must include risk planning, assessing risk areas, developing risk-handling options, monitoring risks to determine how risks have changed, and documenting the overall risk management program. The requirements of the Risk Advisory Board should be developed.

One source of cross-discipline information for the items that need to be considered in developing a Risk Management Plan and Strategy is in the following document: Top Eleven Ways to Manage Technical Risk. It is found on the web at: http://www.abm.rda.hq.navy.mil/p3686.pdf . It offers concise explanations and clear descriptions of steps one can take to establish and implement core technical risk management functions. It contains basic information, explanations, and best practices. It also contains the Risk Management requirements from DoD Directive 5000.1 and DoD Instruction 5000.2, which provide the mandatory policies and procedures for the management of acquisition programs.

The Department of the Air Force Software Technology Center's Guidelines for Successful Acquisition and Management of Software-Intensive Systems, Chapter 6, also provides another good resource for addressing risk management. It builds on the premise that effective risk management depends on the successful integration of both the supplier and buyer's risk management processes.

Additional information is available at DoD websites such as:

http://www.acq.osd.mil/io/se/risk_management/index.htm
http://www.acq.osd.mil/io/se/

d) **Define product metrics** by which the quality of the products will be evaluated **and process metrics** by which the efficiency and effectiveness of the technical effort will be measured. The following program metrics should be collected and analyzed, as a minimum, in order to determine trends; performance strengths and weaknesses; and probability of success.

Program Metrics:

Cost: Projected and Actual Expenditures (BCWP, ACWP, BCWS)
Schedule Compliance: Time allotted and taken, variance
Performance: Requirements met, not met, or deferred
Risks: number and severity
Critical Path: Number of Items along, Performance along
Divergence from historical programs: Novelty, State-of-the-Art
External Dependencies
Staffing

Product Metrics:

Measures of Effectiveness (MOEs) Achievement
Achievement of Key Performance Parameters (KPPs)
Technical Performance Measures (TPMs)
Complexity/Producibility
Requirements Traceability
Requirements and Design Changes: Change Requests pending
Quality and Stability: System Trouble Reports pending, Trend Analysis, Rework
Computer Resource Utilization
Software Metrics: AVDEP-HDBK-7, Rev.1, dated 1 Feb 1996 – Software Metrics Program addresses requirements, size, staffing, quality, capacity, and schedule metrics

Testing Metrics: Requirements identified, tested and passed

Process Metrics: Capability Maturity, Statistical Process Control (SPC)

The Carnegie Mellon Software Engineering Institute website at http://www.sei.cmu.edu/ has additional information.

e) **Establish cost objectives** (e.g., ownership, acquisition, operating, support, and disposal) **to be used in Trade-off analyses**.

Cost as an Independent Variable (CAIV). As part of the DoD Acquisition Reform Initiative to quantify and manage Total Ownership Costs (TOC), CAIV methodology must be established and utilized throughout the entire life cycle of the acquisition process to ensure that operational capability of the total force is maximized for a given investment. CAIV methodology entails the consideration of cost along with required system capabilities; cost is neither dominant nor dependent, but rather a peer with other characteristics. Cost will be formally considered for all Milestones after MS 0 by conducting/updating an analysis that relates cost and all system capabilities to the system's battlefield contribution. This approach is not independent of all work to determine specific capabilities, rather it is part of it. Cost performance analyses will be conducted on a continuous basis throughout the life cycle.

1) CAIV will be applied to ACAT I, II, III programs. ACAT IV programs shall use CAIV as a guideline.

2) PEOs and PMs shall plan for the conduct of cost-performance trade-off studies.

3) Aggressive cost targets for development, procurement, Operations and Support (O&S) and disposal must be established at each milestone review. Progress for achieving cost targets shall be presented at each milestone review.

4) Cost-performance objectives and cost targets shall be included in procurement documents and contractor statements-of-work, as appropriate.

Post Deployment Costs. Life Cycle Management Plans and In-Service Engineering Agent (ISEA) plans should be developed to address post deployment ownership, operating, support, and disposal strategies and costs.

f) **Identify technical performance measures** that will be used to determine the success of the system, or portion thereof, and **that will receive management focus and be tracked using Technical Performance Measurement (TPM) procedures**. This would include incremental measures taken to assess the probability of meeting the objectives. It could include specific measures to determine reliability, maintainability, availability, survivability, testability, safety, electromagnetic properties, weight, balance, and manufacturability. TPMs are derived from MOPs, which reflect system requirements. MOPs are derived from MOEs, which reflect operational requirements. **Sub-process 16** task c) identifies the KPPs.

NOTE: A TPM program provides an early warning of the adequacy of a design in terms of satisfying selected key performance parameter requirements of a system end product. TPM also examines marginal cost benefit of performance in excess of requirements. It also includes sensitivity analysis. A *Key Performance Parameter (KPP)* is one that characterizes a significant total system qualifier. In addition it must be possible to project the evolution of the parameter as a function of time toward the desired value at the completion of development. The projection can be based on verification validation planning or historical data.

g) **Identify applicable tasks** based on analysis of the key events of the project, and the entry and exit criteria for each event.

Work Breakdown Structure (WBS) is the mechanism used to display and define the product to be developed or produced by hardware, software, support, and/or service element, and relates the work scope elements to each other and to the end product(s). It also defines all contractual authorized work. The WBS Dictionary is an important aspect of the work breakdown structure and should be given appropriate attention in development of the WBS. After Contract award, the Project Manager expands the WBS into a Contract Work Breakdown Structure (CWBS) as the initial step in the planning process. WBS expansion will extend the CWBS a minimum of one level below the negotiated external reporting level. This sets up the framework for work scope definitions and assignments to the functional organizations responsible for performing the work. The CWBS is used internally to plan the program in detail and to collect status information on a periodic basis. The adequate number of levels of each CWBS leg extension is determined by the contractual work scope, level, EVMS requirements using the negotiated Cost Performance Reports (CPR) or Cost/Schedule Status Reports (C/SSR) and the Project Manager's management style. The CWBS is not a "people" organization chart; it is a work scope chart.

For Government contracts, use MIL-HDBK-881 (latest revision) as a WBS design guide. MIL-HDBK-881; DoD Handbook -- Work Breakdown Structure; 2 January 1998 is approved for use by all Departments and Agencies of the Department of Defense as guidance, although it cannot be cited as a requirement. The handbook addresses mandatory procedures for those programs subject to DoD Regulation 5000.2-R. It also provides guidance to industry in extending contract work breakdown structures.

Earned Value. In order to objectively define the program baseline cost objectives and track them against performance and schedule, an Earned Value Management System must be established. Earned Value is a management technique used to integrate cost, schedule, technical performance management, and risk management. EVM System Industry Standards (ANSI/EIA-748-1998) Section 2 (defined in the Interim Defense Acquisition Guidebook, formerly DoD 5000.2-R) contains the 32 EVMS Guidelines that should be applied. It mirrors the DoD Earned Value Management Implementation Guide (EVMIG).

Inputs to Earned Value require the project manager to plan, budget and schedule the authorized work scope (as defined in the WBS) in a time-phased plan. As work is accomplished, it is “earned”. Earned Value compared with planned value provides a work accomplished against plan. A variance to the plan is noted as a schedule or cost deviation. Normally the established accounting system provides accumulation of actual cost for the project. The actual cost is compared with the earned value to indicate an over or under run condition. Planned Value, Earned Value, and Actual Cost data provides an objective measurement of performance, enabling trend analysis and evaluation of cost estimate at completion within multiple levels of the project. Through disciplined use of systematic processes, programs are expected to integrate contract work scope, budget, and schedule to achieve a realistic, executable contract plan called the Performance Measurement Baseline (PMB). EVM learning opportunities are an integral part of the various Defense Acquisition University (DAU) short courses, as well as the flagship Representative for Engineering (NAVAIR’s APMSE) course.

Scheduling. This is a key element of the EVMS system, which addresses the time dependency of the acquisition process. The detailed schedule and organization chart based on EVMS is produced in **sub-process 6**. Some parameters that should be considered when developing a schedule to support a successful EVMS process include Accuracy, Reliability, Simplicity, Universality (sufficient from beginning to end of a project), Decision Analysis (enables management to simulate the impact of alternative courses of action), Forecasting, Updating, Flexibility, and Cost. Examples of Scheduling Techniques include: Flow charts, Leadtime charts or Set-back charts, Milestone Charts, Bar Charts, Gantt Chart, Modified Gantt / Milestone charts, Critical Path Method (CPM), Directed Date and PERT.

h) **Identify the appropriate methods and tools, required facilities and equipment, and training required** to be able to complete defined tasks and meet event exit criteria.

Facilities and Equipment. The land, air and sea facilities, laboratories, special fixtures, simulators, and Test Ranges required during the total life cycle of the program must be identified, funded, scheduled, developed and/or procured. Facilities, Laboratories and Ranges should be treated as an integral part of the program planning process. In addition to traditional development and life-cycle support labs, this could include wind tunnels, anechoic chambers, and EMI facilities. The location at which the system is finally deployed and/or operationally tested may be a consideration parameter.

Tools. The following International Council on Systems Engineering (INCOSE) website serves as an excellent reference for identifying the various types of tools:

http://www.incose.org/tools/tooltax/se_tools_taxonomy.html

A summary outline of that information follows:

SE Tools Taxonomy - Management Tools

<u>Configuration Management Tools</u>
<u>Work Flow Management Tools</u>
<u>Risk Management Tools</u>
<u>Cost Estimation and Tracking Tools</u>
- Cost Estimation Tools
- Cost Tracking Tools

<u>Defect Tracking Tools</u>

SE Tools Taxonomy - Engineering Tools

<u>System Design Tools</u>
- System Model Tools
  - Structural Modeling Tools
  - Behavioral Modeling Tools
    - Static Behavioral Tools
    - Dynamic Behavioral Tools
  - HMI Prototyping
- Design Support Tools
  - Simulation Tools
  - Numerical Analysis Tools
  - Domain Specific Tools
  - Measures of Effectiveness Tools

<u>Requirements Engineering Tools</u>
- Requirements Management Tools
  - Requirements Classification Tools
  - Requirements Capture & Identification Tools
    - Textural Requirements Capture Tools
    - Tools for Elicitation of Requirements
  - Requirements Traceability Tools
- Requirements Generation Tools

<u>Design Validation Tools</u>
- Threat Analysis Tools
- Test Validation Planning Tools
- Scenario Validation Tools
- Tools to Validate System Compliance with Requirements
  - Measurement Tools
  - Performance Analysis Tools

Specialty Engineering Tools

SE Tools Taxonomy - Information Sharing Tools
Communication Tools
- Interpersonal Communications Tools
- Network Information Retrieval Tools

Data Analysis Tools
- Spreadsheet Tools
- Data Reduction Tools
- Data Visualization Tools

Electronic Publishing Tools
Electronic Viewing Tools
Tool Integration Facilities

SE Tools Taxonomy - Infrastructure Support Tools
System Administration Tools
Network Support Tools
Product Data Management

i) **Identify applicable or potential technology constraints and develop an approach for overcoming each constraint**, by using an appropriate mitigation approach and by technology insertion at the appropriate time in the enterprise-based life cycle.

Identify constraints on the system including:
- Analysis of Alternatives (AOA): The AOA should assess the critical technologies associated with the system development concepts, including technology maturity and technical risk.
- Use of Commercial Off The Shelf (COTS) equipment
- Use of Non-Development Items (NDI)
- Use of Existing Facilities

Functional and performance requirements must be compared with existing technologies to ascertain feasibility of accomplishment. Any functional or performance constraints imposed by existing technology must be identified. If at this early stage it is known that new technology must be developed, a summary of the development status should be provided. From this status, technical risk and cost should be estimated.

Outputs
All outputs should be archived (SP 12)
- Technical Data Package (TDP) (SP 16)
- Enterprise Data Repository (SP 12)
- Risk Management Strategy (including Risk Advisory Board requirements) (SP 24)
- Program metrics (SP 9)
- Process metrics (SP 9)
- Product metrics (SP 10)
- Testing metrics (SP 11)
- CAIV decision criteria (SP 22)
- Total Life Cycle Cost Objectives (SP 6, 8)
- Technical Performance Measures (TPM) (SP 9, 10, 11, 22)
- Work Breakdown Structure (WBS) (with WBS Dictionary) (SP 2, 6, 7, 9, 10)
- Inputs to Earned Value Management System (EVMS) (SP 8, 9)
- Technology Roadmap (SP 16)
- List of: Methods and Tools, Facilities, Equipment, Training (SP 32)

- Life Cycle Support Plans (SP 16)
- Pre-Plan Product Improvement (P^3I) (SP 16)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agent.
- Total Ownership Cost established
- Risk Management Strategy defined
- EVMS Requirements established
- Metrics identified
- Information repository set up
- Methods, tools, training and facilities identified

Next Processes
Acquisition Process
    Sub-process 2: Product Acquisition
Planning Process
    Sub-process 6: Schedule and Organization
    Sub-process 7: Technical Plans
    Sub-process 8: Work Directives
Assessment Process
    Sub-process 9: Progress Against Plans and Schedules
    Sub-process 10: Progress Against Requirements
    Sub-process 11: Technical Reviews
Control Process
    Sub-process 12: Outcomes Management
Requirements Definition Process
    Sub-process 16: System Technical Requirements
Systems Analysis Process
    Sub-process 22: Effectiveness Analysis
    Sub-process 24: Risk Analysis
System Verification Process
    Sub-process 32: Enabling Products Readiness

Agents
Acquirer: PEO/PM
End User
Systems Engineering
Technical Writer

Tools
WBS Instructions and Plan, EVMS Instructions and Plan

References
Standard across all systems engineering efforts:
- **DoD 5000 Series**
- **Defense Acquisition Deskbook**
- **FAR/DFARs**
- **AT&L Knowledge Sharing System (AKSS)**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

Top Eleven Ways to Manage Risk, ASN/RD&A, October 1998
Capability Maturity Model® Integration (CMMI)^{SM}, **http://www.sei.cmu.edu/**
(especially General Information, Organizational Innovation and Deployment process area, and Measurement and Analysis process area)

Business Case Analysis Risk Assessment Matrix
Managing Quality and Productivity in Aerospace and Defense, November 1989
OSD Commercial Item Acquisition: Considerations and Lessons Learned, 26 June 2000
AVDEP-HDBK-7, Rev.1, dated 1 February 1996 – Software Metrics Program
EIA, Earned Value Management Systems (EVMS), (EIA-748), 1998
MIL-HDBK-881, Work Breakdown Structure; 2 January 1998
ISO 9000
ISO 14000
The Department of the Air Force Software Technology Center's Guidelines for Successful Acquisition and Management of Software-Intensive Systems, Chapter 6

NAVAIR Specific:

- **Draft NAVAIR Risk Management Guide**
- DAU Earned Value Management Department: http://www.dsmc.dsm.mil/educdept/evm_dept.htm
- Earned Value Management System Policy: http://www.dcmc.hq.dla.mil/onebook/2.0/2.2/EVM.htm
- Earned Value Management Implementation Guide: http://www.acq.osd.mil/pm/currentpolicy/jig/evmig1.htm

Metrics and Measures
Risk Cube
EVMS
WBS
Capability Maturity

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process will provide guidance for preparing schedules and applicable technical plans and for identifying resource requirements, and will influence the developer's ability to complete the other applicable processes for engineering a system.

Sub-process 6 – Schedule and Organization

The developer **shall** schedule and organize the defined technical effort.

Provide a task-oriented sequence of events and resources that serves as the roadmap for meeting the plans, objectives and milestones of the customer.

Preceding Process
Acquisition Process
    Sub-process 2: Product Acquisition
Planning Process
    Sub-process 4: Process Implementation Strategy
    Sub-process 5: Technical Effort Definition
Requirements Definition Process
    Sub-process 16: System Technical Requirements

Inputs

- Acquisition strategy (SP 2)
- Total Life Cycle Cost Objective (SP 5)
- System Technical Requirements (SP 16)
- Work breakdown structure (WBS) (SP 5)
- Life Cycle Phase Chart (Milestones) (SP 4)
- Process Implementation Strategy (SP 4)

Interim Defense Acquisition Guidebook (formerly DoD 5000-2R) requires all major acquisition programs (ACAT I and II) to have an Acquisition Program Baseline (APB). This document contains key milestones and events for the program (i.e., MS-A (Technology Development), MS-B (System Development and Demonstration (SDD)), MS-C (Production and Deployment), Initial Operational Capability (IOC), etc.). However, be aware that for most programs this document doesn't exist so other means must be used to obtain similar data that is expressed in the APB document. For most programs, important schedule information is provided by the sponsor (acquirer) or program office through formal and informal channels. We recommend that this information be provided through formal channels.

All programs have constraints that must be known at the time of inception. The SE has to know and understand the cost, schedule, and performance constraints and thresholds. These constraints must be known before any realistic schedule can be developed. This information should be discussed with the system acquirer and formally documented and communicated to the team.

System Technical Requirements serve as the basis for scheduling technical activities. Knowing the technical requirements can help in analyzing various schedule options and lead times associated with activities required to deliver the system solution. For example, hardware solutions may require different activities, skills and schedules than software solutions. A Helicopter aircraft solution may require different activities and solutions than a fixed-wing aircraft.

A properly prepared WBS serves as a good top-level source for identifying what needs to be done for the entire program. A schedule should be identified for each element of the WBS. The level of the WBS normally dictates the level of schedule information that will be tracked in a common database within the program. Lower level elements are normally tracked at the lower element level WBS.

Milestones serve as a metric of progress and also normally identify a decision point for management. The Acquirer normally identifies program milestones, and the SE identifies technical milestones within the scope of the program milestones. Most programs have a milestone for program go-ahead, contract award or, in the case of a field activity, issuance of a task statement, test milestones (DT & OT), initial operational capability (IOC) and production milestones.

Entry Criteria

Inputs have been approved by the appropriate agent.

- Milestone approval
- Receipt of funding
- Request from Acquirer

Tasks

The developer **should** plan to do the appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Develop an event-based schedule that integrates key events (internal and external), related tasks, specialty engineering tasks, and relevant completion criteria for the applicable enterprise-based life-cycle phase**. This task is accomplished based on the scope and definition of the technical effort identified in **Sub-process 5**. Navy, prime contractor, and sub-contractors must generate definition of tasks and responsibilities. These organizations must sign-up to produce the products contracted for, to be accountable to the next higher level of product development and integration, and to support the integration of their product as part of the total system integration. This assignment of tasks and responsibilities completes the development of the WBS initiated under **Sub-process 5**.

b) **Develop the calendar-based schedule, showing the dates of expected task and event completions and the dependency relationships among tasks, with the goal of developing information for an Integrated Master Schedule (IMS)**. The IMS is the integrated schedule of the program. It is used for identification of problem areas during program planning and execution and to help define priorities for management attention and action, particularly as problem areas develop and are identified. As changes appear to be required, the schedule is used as a basis for evaluating changes and is a significant tool for

communicating the program content, workflow, and approach. Since progress can be compared to planned progress, the schedule is a key ingredient to providing performance measurement and evaluating remaining work scope and duration.

The IMS is the tool that provides the detailed tasks and timing of the tasks that support the work effort the Integrated Master Plan (IMP) delineates. It supports all the criteria, accomplishments, and events of the IMP. It includes process tasks as required to insure the fully integrated plan for the content of the program. The IMS ties them together by showing their logical relationships, any interrelationships between pieces of work, and any constraints that control the start or finish of each piece of work. Thereby, the IMS becomes the source that depicts the planned dates when each event is expected to occur as well as all the expected dates for all work done to get to the event. We recommend that you use software tools to track and show dependency relationships. These tools offer the user the advantage of quickly performing changes and sensitivity analysis.

c) **Identify resources required to complete scheduled tasks**. Skills, man-years, and cost should be identified and considered in the overall schedule and organization of each phase of the program. Facilities such as national assets and unique assets must be considered in the schedule along with key events.

d) **Define the staffing and discipline needs to complete the scheduled tasks, training needs, and risks if required staff are not available**. Staffing is very often forgotten but is a key component to successful and complete scheduling of program tasks. The systems engineer should understand the scope of the technical effort identified in **Sub-process 5** and identify the staffing required for program success. The systems engineer should properly phase the technical staffing needs of the program. Consideration should be given to availability of expertise to coincide with the program technical effort needs. Appropriate subject matter experts cannot always be made available based on demand and location of limited resources (funding resources or human resources). Staffing may drive schedule or schedule may drive staffing depending upon resources available.

e) **Define the team and organizational structure to complete the scheduled tasks within resource constraints**. For NAVAIR, this is the Program Operating Guide (POG), which should exist for most major programs. This guide is useful in providing the IPT structure, key individuals and support activities, resources and man-year information, and also program timelines and events that are important for a twelve-month period. The POG is used to lay out a Program Manager's plan and guidance for the concept of Integrated Program Teams (IPTs) and their relationship to the Competency Aligned Organization, and to clearly communicate the Program's organizational structure to the Program's workforce, the Program Executive Officer (PEO) and the NAVAIR leadership. It identifies the goals, objectives and attributes of the team and is updated on an as required basis.

Outputs

All outputs should be archived (SP 12)

- Resource requirements (staffing, cost) (SP 7)
- Organizational structure (SP 5, 7, 8)
- Integrated Master Schedule (IMS) (SP 2, 5, 7, 8, 9, 10, 11, 21)

NAVAIR Specific:

- Program Operating Guide (POG) (SP 5)

Exit Criteria

Outputs have been reviewed and approved by the appropriate agent.

- All tasks and work allocated plus resources identified.
- Firm organizational structure

Next Processes

Acquisition Process

Sub-process 2: Product Acquisition

Planning Process
    Sub-process 5: Technical Effort Definition
    Sub-process 7: Technical plans
    Sub-process 8: Work Directives
Assessment Process
    Sub-process 9: Progress Against Plans and Schedules
    Sub-process 10: Progress Against Requirements
    Sub-process 11: Technical Reviews
Control Process
    Sub-process 12: Outcomes Management
Transition to Use Process
    Sub-process 21: Transition to Use

Agents
Acquirer, Systems Engineering, User, Specialty Engineering, Logistics

Tools
Scheduling Tools (ex. MS Project, Open Plan, Simplicity, Primavera)
Estimating Tools (ex. COCOMO, SEER-SEM, Function Points)

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
  - **DoD 5002. R** (C1.4 acquisition program baseline; C5.2 Systems engineering; AP4 EVMS; C6.1Test & evaluation)
- **Defense Acquisition Deskbook**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

DI-MISC-81183A Integrated Master Schedule Data Item Description (DID)
Capability Maturity Model® Integration (CMMI℠), 2001: Project Planning and Integrated Project Management process areas

Metrics and Measures
Schedule variance (SV)
Cost variance (CV)
Staffing
Percent complete

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process provide guidance for preparing applicable technical plans used to guide completion of the technical efforts for each applicable process to meet agreement requirements.

Sub-process 7 – Technical Plans

The developer **shall** create technical plans to ensure an integrated and cost effective technical effort in accordance with the defined schedule and organization.

Preceding Process
Planning Process
    Sub-process 4: Process Implementation Strategy
    Sub-process 5: Technical Effort Definition

Sub-process 6: Schedule and Organization
Requirements Definition Process
Sub-process 14: Acquirer Requirements

Inputs

- Capability Development Document (CDD) or Capability Production Document (CPD) – formerly Operational Requirements Document (ORD) (SP 14)
- Initial Capabilities Document (ICD) – formerly Mission Needs Statement (MNS) (SP 14)
- Measures of Effectiveness (MOE) (SP 14)
- Process Implementation Strategy (SP 4)
- Work Breakdown Structure (WBS) (SP 5)
- Integrated Master Schedule (IMS) (SP 6)
- Organizational Structure (SP 6)
- Resource Requirements (SP 6)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents.

- Key milestones established.
- Technical effort and organization defined.

Tasks

The developer should prepare appropriate plans to complete this sub-process. Systems engineering planning addresses the scope of the technical effort required to develop the system. The basic questions of "who will do what" and "when" must be answered. A technical plan describes what must be accomplished, how systems engineering will be done, how the effort will be scheduled, what resources will be needed, and how the effort will be monitored and controlled. The number and type of plans will vary depending on the scope, life-cycle phase, and other factors. Appendix D of this document contains a list of typical technical plans. **Plans to consider include the following**:

a) **Engineering Plan**. For most Navy and Marine Corps programs, this implies a Systems Engineering Plan (SEP), formerly Systems Engineering Management Plan (SEMP). On major programs the SEP is a contract deliverable and is prepared by the prime contractor. Guidance on the content and format of a SEP (e.g., SEMP) can be found in the DAU publication "Systems Engineering Fundamentals" and in the APMSE Quick Reference Guide. Also see the list of questions in Table C.7 for ideas on what information the SEP needs to provide. Another source of guidance is **DI-MGMT-81024**.

   The Software Development Plan (SDP) is the equivalent of a SEP when the system under development is purely software and for the software component of a system. Guidance on the content and format of an SDP can be found in ISO/IEC 12207. On programs that are procuring software intensive systems, the planning information should be incorporated into the corresponding sections of documents such as the Acquisition Plan and the SEP.

b) **Risk Management Plan**. The development of the Risk Management Plan supports **Sub-process 24**, Risk Analysis, and is based on the Risk Management Strategy developed in **Sub-process 5**. The Risk Management Plan should address the elements of Risk Management including Risk Identification, Risk Analysis, Risk Assessment, and Risk Handling. Plans for a Risk Management Board and Risk Reporting should be defined. Also see the DAU Publication "Risk Management Guide for DoD Acquistion" and NAVAIRINST 5000.21, NAVAIR Program/Project Risk Management. .

c) **Technical Review Plan**. A review plan shall identify any significant technical reviews required, when they will occur, and the purpose of the review. Typically the Review Plan is not a stand-alone document but is incorporated in the SEP (task a) above) and in other program documentation. The normal sequence of reviews for a typical system is: System Requirements Review (SRR); System Functional Review/Software Specification Review (SFR/SSR); Preliminary Design Review (PDR); and Critical Design Review/Test Readiness Review (CDR/TRR). The nomenclature and acronyms for

these reviews are often modified for specific programs, but the purpose of the reviews should not change. The DoD 5000 series provides guidance on the timing of major reviews relative to milestones. NAVAIR Instruction 4355.19B describes the NAVAIR Systems Engineering Technical Review Process to be used for technical and design reviews. When preparing a technical review plan, coordination is required to ensure that the appropriate contractors are tasked in the SOW to support the reviews, and that, if reviews are tied to entry/exit criteria for milestone decisions, it is reflected in the plan. A sample of an event-based schedule of reviews is contained in Appendix A of the **DAU Systems Engineering Fundamentals**.

d) **Verification Plans**. Verification, as well as Validation (task e) below), is usually accomplished via some form of testing. The relationships of the various test plans are shown in Figure 4.2.1b

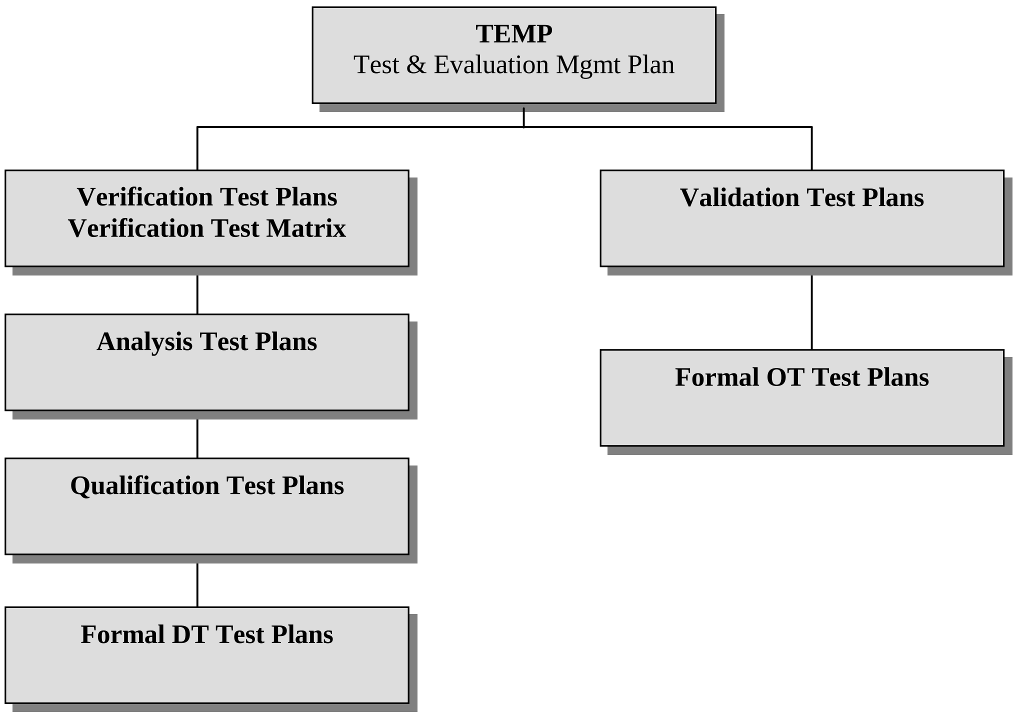


Figure 4.2.1b – Test Plan relationships

Verification Plans take many forms depending on the life-cycle phase and program content. Sub-processes 30-32 require Verification Plans that are often very informal and consist only of a Verification Matrix. A Verification Matrix shows how every requirement will be verified such as by analysis, modeling and simulation, lab test, or full-scale test. For certain critical systems, such as digital flight control systems, a separate group may perform verification and validation tasks independent of the developer. These efforts will be defined in the Independent Verification & Validation (IV&V) Plan, **DI-NDTI-80566**.

Sub-process 30, Design Solution Verification, is usually addressed through a series of more detailed verification plans or Qualification Test Plans. Qualification Tests are usually conducted by the contractor in a laboratory or chamber and consist of tests such as temperature/altitude, shock, vibration, and EMI for "black box" type systems or static strength or fatigue tests for mechanical or structural systems. Plans for these types of tests are tailored for the environment for which the system is being designed based on requirements defined in the system specification. These tests are typically defined in the contractor's SOW and the verification (qual) test plans are written by the contractor and approved by the government.

Sub-process 31, End Product Verification, implies a formal DT (Developmental Testing) period, which includes both testing performed by the contractor or developer and testing performed by a government or integrated test team. The overarching plan for testing of any system is usually the Test and Evaluation Management Plan (TEMP). Guidelines for TEMP preparation are contained in the DoD 5000 series documents. TEMP preparation is the responsibility of the Program Manager and requires the concurrence of all key parties such as DOT&E, COMOPTEVFOR, N-912, the resource sponsor, and the PEO. Test plans for specific DT tests are usually developed by the testing activity (such as NAWCWD or NAWCAD) and are prepared in their format. Contractor test plans are usually prepared as a contract deliverable for government approval prior to the start of each phase of testing such as EMI testing. Major programs usually have a Test and Evaluation Process Working Group (TEPWG), which has the responsibility and oversight for preparation and planning of all major DT events.

e) **Validation Plans**. Planning for validation (OT for major programs) is encompassed in the TEMP. A detailed OT Test Plan is prepared by the OT Test Activity (e.g., VX-9) and approved by COMOPTEVFOR.

f) **Other applicable plans as called for in the agreement or by enterprise policies and procedures** such as a Configuration Management Plan, Quality Assurance Plan, Data Management Plan, Manufacturing Plan, Source Selection Plan, and Security Management Plan. Sample outlines for some of these plans are listed below:

Manufacturing Plan (see DID –**DI-MISC-81180**)

(1) Introduction – Background, Manufacturing Organization, Management System
(2) Manufacturing Management Program – Time Phased Schedule, Manpower Plan, Industrial Facilities Capacity Assessment, Risk Assessment, and Capital Investment Commitment
(3) Manufacturing Program Planning – Producibility Plan, Make or Buy Criteria, Supplier Management, Methods and Production Flow, Tooling and Special Test Equipment, Productivity Improvement, Industrial Materials Management
(4) Manufacturing Management Data
(5) Audits
(6) Labor Relations

QA Plan (see ISO 9001)

(1) Quality Management System
(2) Management Responsibility
(3) Resource Management
(4) Product Realization
(5) Measurement, Analysis, and Improvement

Parts Management Plan

Use MIL- HDBK-512 as guidance and a source of additional reference material.

Configuration Management Plan

Use MIL-HDBK-61 as guidance. NAVAIR INST 4130.1C provides details on the CM process. Requirements for a contractor's Configuration Management Plan are found in DI-CMAN-80858B.

Source Selection Plan (SSP)

Refer to **Appendix D** for various types of plans that may be considered for development by this sub-process.

Outputs

All outputs should be archived (SP 12)

- System Engineering Plan (SEP) and/or Software Development Plan (SDP) (SP 9, 10, 11, 22, 24, 30)
- Test and Evaluation Management Plan (TEMP) (SP 2, 11, 30, 31, 33)
- Risk Management Plan (SP 24)
- Computer Resources Life Cycle Management Plan (CRLCMP) (SP 9)
- Configuration Management Plan (SP 5, 9)
- Quality Assurance (QA) Program Plan (SP 20)
- Manufacturing Plan (SP 20)
- Data and Document Management Plan (SP 5, 13)
- Security Management Plan (SP ALL)
- Verification Plan (including the Verification Compliance Requirement Matrix (VCRM)) (SP 25, 30, 31)
- Validation Plan (to include what NAVAIR calls Operational Test Plan and Developmental Test Plan) (SP 11, 25, 26, 27, 28, 29, 33)
- Independent Verification and Validation (IV&V) Plan (SP 30)
  (for early development testing typically for software, done by a 3rd party)
- Source Selection Plan (SSP) (SP 2)

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents.
All technical plans identified, written, and approved.

Next Processes

Acquisition Process
    Sub-process 2: Product Acquisition
Planning Process
    Sub-process 5: Technical Effort Definition
Assessment Process
    Sub-process 9: Progress Against Plans and Schedules
    Sub-process 10: Progress Against Requirements
    Sub-process 11:Technical Reviews
Control Process
    Sub-process 12: Outcomes Management
Implementation Process
    Sub-process 20: Implementation
Systems Analysis Process
    Sub-process 22: Effectiveness Analysis
    Sub-process 24: Risk Analysis
Requirements Validation Process
    Sub-process 25: Requirements Statements Validation
    Sub-process 26: Acquirer Requirements Validation
    Sub-process 27: Other Stakeholder Requirements Validation
    Sub-process 28: System Technical Requirements Validation
    Sub-process 29: Logical Solution Representations Validation
System Verification Process
    Sub-process 30: Design Solution Verification
    Sub-process 31: End Product Verification
End Products Validation Process
    Sub-process 33: End Products Validation

Agents

Acquirer, Systems Engineering, Program Manager, Test Engineers, COMOPTEVFOR, Contractors

Tools

Planning and scheduling tools (ex. Microsoft Project)
Automated Systems Engineering tools (ex. CORE™, SLATE™)

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals** (Chapter 16)
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

DI-MGMT-81024, Systems Engineering Management Plan (SEMP)
DI-NDTI-80566
DI-MISC-81180
Capability Maturity Model® Integration (CMMI^{SM}), 2001: Project Planning process areas
Earned Value Management System (EVMS) Industry Standards (EIA-748), 1998
DI-CMAN-80858B, Contractor's Configuration Management Plan
ISO/IEC 12207
IEEE 1220
DAU: Risk Management Guide for DoD Acquisition
ISO 9001
MIL- HDBK-512A
MIL-HDBK-61A

NAVAIR Specific:

- **NAVAIR INST 4130.1C** Configuration Management Policy
- **NAVAIR INST 4355.19B** Systems Engineering Technical Review Process
- **NAVAIR INST 5000.21** Program/Project Risk Management
- **APMSE Quick Reference Guide**

Metrics and Measures
Plans completed and released on time.

The expected outcomes for the tasks related to developing these plans are provided in **Appendix C**. The outcomes associated with completing this sub-process provide guidance for preparing work directives and completing other applicable project processes for engineering a system.

Any plan created **should** include the scope, tasks, methods, tools, metrics, risks, and resources as applicable to fulfill the purpose of the plan.

> NOTE – **Appendix D** of this Guide contains a listing of typical planning documents. Some projects require either more or significantly less documentation. These planning documents can be tailored as to the level and formality of planning to suit project complexity and uncertainty.

Sub-process 8 – Work Directives

The developer **shall** create work directives that implement the planned technical effort.

Preceding Process
Acquisition Process
    Sub-process 2: Product Acquisition
Planning Process
    Sub-process 4: Process Implementation Strategy
    Sub-process 5: Technical Effort Definition

Sub-process 6: Schedule and Organization
Requirements Definition
Sub-process 16: System Technical Requirements

Inputs

- Process Implementation Strategy (SP 4)
- Life Cycle Phase Chart (SP 4)
- Total Life Cycle Cost Objectives (SP 5)
- Life-cycle phase exit criteria (SP 4)
- Organizational Structure (SP 6)
- Integrated Master Schedule (SP 6)
- Inputs to Earned Value Management System (EVMS) (SP 5)
- Cost, schedule, and performance constraints (SP 2)
- System Technical Requirements (SP 16)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents.

Tasks

The developer **should** plan to do appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Develop individual project team or organization work packages that describe the work to be done, resource sources, schedules, budget, and reporting requirements**.

Statement of Work (SOW). The Statement of Work (SOW) is a portion of a contract which establishes and defines all non-specifications requirements for contractors' efforts either directly or with the use of specific cited documents. See MIL-STD-245D.

Statement of Objectives (SOO). The Statement of Objectives (SOO) is a portion of a contract which establishes a broad description of the governments' required performance objectives.

Team Work Plan (TWP). The Team Work Plan (TWP) addresses labor by category, material, travel, flight costs, expendables, range requirements and laboratory requirements. The TWP might include: a program summary, cancellations, references, and/or enclosures; technical instructions; schedule; reports and documentation to be provided; future planning information; contractual authority; source and disposition of equipment; and security classifications.

b) **Generate work authorizations for the team or organization that provide approval for applicable teams or organizations to complete their work package requirements and to release applicable resources**.

<u>NAVAIR Specific</u>:

Team Assignment Agreement (TAA). NAVAIR has instituted the Team Assignment Agreement (via NAVAIRINST 5400.154 dated 15 August 2000) as the vehicle to establish the process and procedures within NAVAIR for the assignment of its personnel to Teams. It documents the method to be used to describe the work to be done, resources, schedules, funding, and reporting requirements for competency support. The program offices may use a different mechanism for setting their internal resource requirements.

The final product is the signed Team Assignment Agreement (TAA) that meets both the program and competency requirements. The TAA should address the following: tasks, functions, products, and/or services to be provided; funding summary; availability/duration of resources; authority/empowerment level; training requirements and agreements; collocation requirements; performance evaluation inputs

required; administrative functions delegated to Team leadership; and the issue resolution process to be employed.

Outputs

All outputs should be archived (SP 12)

- Team Work Plan (TWP) (SP 2, 15, 30)
- Statement of Objectives (SOO) (SP 2, 15, 30)
- Statement of Work (SOW) (SP 2, 15, 30)

NAVAIR Specific:

- Team Assignment Agreement (TAA) (SP 1)

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents.
(TAA Signed, WBS defined)

Next Processes

Supply Process
Sub-process 1: Product Supply
Acquisition Process
Sub-process 2: Product Acquisition
Control Process
Sub-process 12: Outcomes Management
Requirements Definition Process
Sub-process 15: Other Stakeholder Requirements
System Verification Process
Sub-process 30: Design Solution Verification

Agents

Acquirer: PEO/PM, IPT, Systems Engineering, Logistics

Tools

WBS
TAA Form

References

Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

Earned Value Management System (EVMS) Industry Standards (EIA-748), 1998
MIL-HDBK-881 Work Breakdown Structure; 2 January 1998
MIL-STD-245D

NAVAIR Specific:

- **NAVAIR TAA Instruction (NAVAIRINST 5400.154)**

Metrics and Measures

Risk Cube
EVMS
WBS
Capability Maturity

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process provide the means to implement the planned technical effort.

4.2.2 Assessment Process

The Assessment Process is used to: (1) determine progress of the technical effort against both plans and requirements; (2) review progress during technical reviews; and (3) support control for the engineering of a system. The product and process metrics selected for assessing progress should provide information for risk aversion, meaningful financial and non-financial performance, and support of project management.

> NOTE – When variations are sufficiently significant or cannot be corrected by re-accomplishment of the process tasks that generated the outcome data, the Planning Process is re-initiated in order to implement appropriate corrective actions.

The three sub-processes associated with the Assessment Process are shown in Figure 4.2.2a.

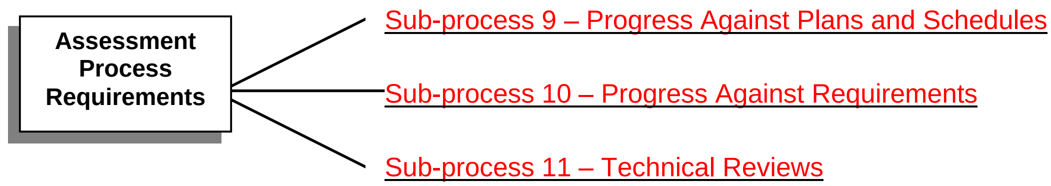


Figure 4.2.2a – Assessment Process/Sub-processes

Inputs to the Assessment Process are in the form of technical plans, stakeholder requirements, and engineering outcomes from other processes. The relationships of the Assessment Process/Sub-processes are shown in Figure 4.2.2b.

These sub-processes use metrics produced by an EVM system (see **Sub-process 5**) to track the progress of the processes. Product technical requirements essential to the system being acquired are also tracked. **Sub-process 9** uses metrics to track the progress against the program plans and schedules used to manage the program, while **Sub-process 10** tracks the progress in meeting product-related technical requirements. **Sub-process 11** provides a status of design maturity and requirement satisfaction, identifies risks and issues to be resolved and determines whether the system is ready for the next engineering phase. Cost, schedule and performance variances reflected in the metrics are fed into a risk management system (see **Sub-process 24**), which produces a risk management system with risk mitigations identified, the effect of which can be observed and adjusted. A program, which does not employ a closed loop to feed EVM system variances into the risk management system cannot be effective in making positive changes in the management of the system.

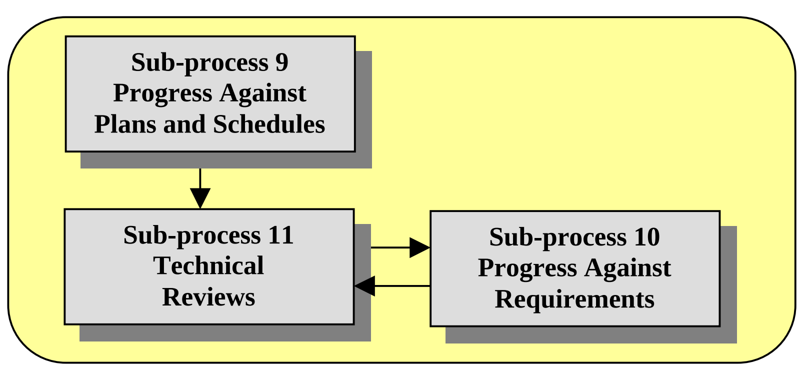


Figure 4.2.2b – Assessment Process/Sub-processes relationships

Sub-process 9 – Progress Against Plans and Schedules

The developer **shall** assess the progress of the program effort against applicable plans, schedules, and budgets.

Preceding Process
Planning Process
Sub-process 5: Technical Effort Definition
Sub-process 6: Schedule and Organization
Sub-process 7: Technical Plans
Systems Analysis Process
Sub-process 23: Trade-off Analysis

Inputs
- Technical Performance Measurements (TPM) (SP 5)
- Work Breakdown Structure (WBS) (SP 5)
- Inputs to Earned Value Management System (EVMS) (SP 5)
- Program metrics (SP 5)
- Process metrics (SP 5)
- Integrated Master Schedule (IMS) (SP 6)
- Systems Engineering Plan (SEP) or Software Development Plan (SDP) (SP 7)
- Computer Resources Life Cycle Management Plan (CRLCMP) (SP 7)
- Configuration Management Plan (SP 7)
- Trade-off Analysis Technical Report (SP 23)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agent.

Tasks
The developer **should** plan to do appropriate tasks to complete this sub-process using an Earned Value Management System (EVMS) as described in **Sub-process 5**. Tasks to consider include the following:

a) **List the appropriate events such as system specification, design reviews, tasks, and process metrics, including capability maturity, for monitoring progress against plans and schedules**.

b) **Collect and analyze identified process metrics data and results from completion of planned and scheduled tasks and events**, which will be used to conduct trend analyses. Assess the program's schedule performance status by examining data produced by an EVMS. Compare the actual or forecast dates and durations to the targeted dates and durations. Collect the number of actual hours worked from the accounting system.

c) **Compare process metrics data against plans and schedule using trend analysis to determine technical areas requiring management or team attention**. Compare the actual or forecast hours to target hours. Continually identify and manage critical path activities.

d) **Determine risk and identify need to correct variances, make changes to plan and schedule, and redirect work because of risk**.

Outputs *(List of sub-processes where output is used may include the originating sub-process.)*
All outputs should be archived (SP 12)
- List of appropriate events, tasks, and process metrics (SP 9)
- Process metrics data (SP 9)
- Program metrics data (SP 9)

- Plans and schedules trend analysis (SP 3, 9, 11, 12, 23, 24)
- Cost Performance Report (CPR or C/SSR) (SP 12)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agent.

Next Processes
Acquisition Process
    Sub-process 3: Supplier Performance
Assessment Process
    Sub-process 11: Technical Reviews
Control Process
    Sub-process 12: Outcomes Management
Systems Analysis Process
    Sub-process 23: Trade-off Analysis
    Sub-process 24: Risk Analysis

Agents
Acquirer
Stakeholder
Program Management
Systems Engineering
Logistics
Cost

Tools
Requirements Management & System Architecture Database (ex. CORE™, DOORS, SLATE™)
Schedule software with Insight (ex. MS Project, Open Plan Professional, Primavera, etc)
Completion Date Histogram
Logic Diagrams
Gantt Bar Charts
Milestone Charts
Resource/Hour Usage Charts
Earliest, Expected and Latest Completion Dates and Durations

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

Earned Value Management System (EVMS) Industry Standards (EIA-748), 1998
DAU Program Manager's Tool Kit, 2004
DRAFT **MIL-STD-499B** Systems Engineering
Capability Maturity Model® Integration (CMMI℠), 2001: Project Monitoring and Control process areas

NAVAIR Specific:

- **NAVAIR Acquisition Guide**
- **NAVAIRINST 4355.19B**, Systems Engineering Technical Review (SETR) Process

Metrics and Measures

Percent EVMS that is not level of effort
Accuracy of trend analysis
Amount of time between the closing of a reporting period and the reporting of a metric
Number of team members that have access to their appropriate metrics
IPT member satisfaction with the metrics
Provided EVMS metrics used

The expected outcomes for these representative tasks are provided in in **Appendix C**. The outcomes associated with completing this sub-process provide status information to enable efficient use of resources, evaluation of progress against plan, identification of variances of cost and schedule from planned project management baselines, and early identification and resolution of productivity problems.

NOTE – *Process metrics* are identified and used to assess the means of attaining stakeholder satisfaction. Process metrics include earned value (cost/schedule measure), amount of waste, number of engineering changes, percentage of drawings completed, number of drawing errors, percentage of lines of code completed, rework percentage, idle time (e.g., work in progress), change rate, and turnover in personnel. The criteria for process metric selection are based on how well enhancement in project performance correlates with improvement in potential customer satisfaction.

Sub-process 10 – Progress Against Requirements

The developer **shall** assess the progress of system development by comparing currently defined system characteristics against requirements.

Preceding Process
Planning Process
  Sub-process 5: Technical Effort Definition
  Sub-process 6: Schedule and Organization
  Sub-process 7: Technical Plans
Assessment Process
  Sub-process 11: Technical Reviews
Requirements Definition Process
  Sub-process 14: Acquirer Requirements
  Sub-process 16: System Technical Requirements
System Verification Process
  Sub-process 30: Design Solution Verification
  Sub-process 31: End Product Verification

Inputs
- Initial Capabilities Document (ICD) – formerly Mission Needs Statement (MNS) (SP 14)
- Capability Development Document (CDD) – formerly Operational Requirements Document (ORD) (SP 14)
- Systems Engineering Plan (SEP) or Software Development Plan (SDP) (SP 7)
- Technical Performance Measurements (TPM) (SP 5)
- Work Breakdown Structure (WBS) (SP 5)
- Key Performance Parameters (KPP) (SP 16)
- Product metrics (SP 5)
- Integrated Master Schedule (IMS) (SP 6)
- Technical review report (SP 11)
- Design solution deficiency and discrepancy reports (SP 30)
- End product deficiency and discrepancy reports (SP 31)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agent.

Develop enterprise architecture data that includes, but not limit to, program goals, thresholds, objectives, user requirements, cost, schelude, and performance parameters. The architecture data should be in a Core Architectural Data Model (CADM)-base repository or CADM compliance repository, which can be used to assess system capabilities and shortfalls and to include the associated costs and schedule for providing those capabilities.

Tasks
The developer **should** plan to do appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Identify product metrics, and their expected values, that will affect the quality of the product and provide information of the progress toward satisfying acquirer and other stakeholder requirements, as well as derived requirements**. Integrated Product team (IPT) leaders or functional managers identify Key Performance Parameters (KPPs) and Technical Performance Measures (TPMs) to be tracked. (See **Sub-process 5**.) TPMs are added or deleted, or parameters adjusted as the program progresses to ensure that an appropriate set of key performance requirements is being monitored (and managed).

b) **Collect and analyze product metrics data**. This is typically done by the IPT to conduct trend analysis. Examples might include, power, sensitivity, vibration, fuel consumption, weight, balance and software function points. A technical compliance matrix is used to compare actual progress with the requirements baseline (or plan).

c) **Record rationale for decisions and assumptions made with respect to collected data**.

d) **Compare results against requirements to determine degree of technical requirement satisfaction, progress toward maturity of the system (or portion thereof) being engineered, and variations and variances from requirements**.

e) **Identify deficiencies and discrepancies to specifications and configuration baselines**. This is important to Sub-process 5, Sub-process 7, and Sub-process 14 to consider revisions to technical approaches, requirements and/or plans in the event that it appears that one or more requirements will not be able to be met as presently defined. It may be necessary to change a technical approach or revise a requirement if the requirements cannot be met.

Outputs
All outputs should be archived (SP 12)
- Requirement trend analysis (requirement satisfaction, system maturity, technical compliance matrix) (SP 3, 11, 23, 24)
- Deficiencies and discrepancies (SP 11, 19)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agent.

Next Processes
Acquisition Process
    Sub-process 3: Supplier Performance
Assessment Process
    Sub-process 11: Technical Reviews
Control Process
    Sub-process 12: Outcomes Management
Solution Definition Process
    Sub-process 19: Specified Requirements
Systems Analysis Process
    Sub-process 23: Trade-off Analysis

Sub-process 24: Risk Analysis

Agents
Program Management
Systems Engineering
Logistics
Cost

Tools
Requirements Management & System Architecture Database (ex. CORE™, DOORS, SLATE™)
Schedule software w/Insight (ex. MS Project, Open Plan Professional, Primavera, etc)

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

Earned Value Management System (EVMS) Industry Standards (EIA-748), 1998
DAU Program Manager's Tool Kit, 2004
DRAFT **MIL-STD-499B** Systems Engineering
Capability Maturity Model® Integration (CMMI℠), 2001: Project Monitoring and Control process areas

NAVAIR Specific:

- **NAVAIR Acquisition Guide**
- **NAVAIRINST 4355.19B** Systems Engineering Technical Review (SETR) Process

Metrics and Measures
Percent requirements (appropriate to the level of development) that have been analyzed, and percent deficiencies and discrepancies identified and reported to the appropriate agents.

The expected outcomes for these representative tasks are provided in **Appendix C**. Representative outcomes associated with completing this sub-process provide: (1) an evaluation of the progress toward meeting requirements pertaining to the system being engineered or reengineered; (2) status information to enable efficient use of resources; (3) evaluation and tracking of system quality and technology; (4) faster response time to inquiries from acquirer or other stakeholders; (5) identification of variances from planned improvements in critical technical parameters as the design evolves; (6) early identification and resolution of system related problems; and (7) tracking trade-off analysis and analysis of alternative recommendations, effectiveness analysis results, verification outcomes, and validation results.

> NOTE – Product metrics are used to measure stakeholder satisfaction, deliver an ever-improving value to the acquirers of system end products, and be indicative that the design process is continuing toward an acceptable solution. An example of an input product metric is the quality of materials and skills of assigned project personnel. An example of an output metric is a Technical Performance Measure (TPM).

Sub-process 11 – Technical Reviews

The developer **shall** conduct technical reviews of progress and accomplishments in accordance with appropriate technical plans.

Preceding Process

Planning Process
    Sub-process 5: Technical Effort Definition
    Sub-process 6: Schedule and Organization
    Sub-process 7: Technical Plans
Assessment Process
    Sub-process 9: Progress Against Plans and Schedules
    Sub-process 10: Progress Against Requirements
    Sub-process 11: Technical Reviews
Requirements Definition Process
    Sub-process 14: Acquirer Requirements
    Sub-process 16: System Technical Requirements
Solution Definition Process
    Sub-process 19: Specified Requirements
System Verification Process
    Sub-process 30: Design Solution Verification
    Sub-process 31: End Product Verification

Inputs

- Initial Capabilities Document (ICD) – formerly Mission Needs Statement (MNS) (SP 14)
- Capability Development Document (CDD) – formerly Operational Requirements Document (ORD) (SP 14)
- Testing metrics (SP 5)
- Technical Performance Measurements (TPM) (SP 5)
- Integrated Master Schedule (IMS) (SP 6)
- Validation Plan (SP 7)
- Systems Engineering Plan (SEP) or Software Development Plan (SDP) (SP 7)
- Test & Evaluation Master Plan (TEMP) (SP 7)
- Plans and schedules trend analysis (SP 9)
- Requirement trend analysis (SP 10)
- Deficiencies and discrepancies (SP 10)
- Systems Requirements Document (SP 16)
- System technical requirements (SP 16)
- Specified requirements (SP 19)
- Design solution deficiency and discrepancy reports (SP 30)
- End product deficiency and discrepancy reports (SP 31)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agent.

Tasks

Technical reviews are conducted to ensure that the product being developed meets the requirements for the appropriate anticipated level of maturity. Each review must have defined entry and exit criteria tied to the required level of design maturity and applied across all requirements and technical disciplines.

The developer **should** plan to do appropriate tasks to complete this sub-process. Within NAVAIR, NAVAIRINST 4355.19B establishes the policies and responsibilities for conducting technical reviews, a detailed description of the types of reviews, and the duties of participants.

Tasks to consider include the following:

a) **Identify the review objectives and requirements cited in the Systems Engineering Plan (SEP); enterprise policies and procedures; and agreement, as applicable**.

b) **Verify completion of the technical review entry requirements**.

1) Identify the anticipated completion at that stage of maturity (TPMs, drawings) evaluated against the anticipated status/requirements.

2) Confirm that necessary reviews, inspections, tests, processes, deliveries, and coding were completed properly as specified/required.

c) **Establish the technical review board, agenda, and speakers**.

d) **Prepare the appropriate materials to include in the read-ahead technical review package and presentation package**.

e) **Facilitate and support identification and resolution of emerging issues prior to the review**.

f) **Conduct the technical review using the guidance of the Design Review Handbook according to the SEP, identifying and documenting action items required to meet the review objectives**.

1) Evaluate the design for compliance with known technical requirements.
2) Verify interfaces compatibility.
3) Determine what issues remain to be resolved.
4) Verify that the emerging design is ready to enter the next stage of development.
5) Verify that the product is testable, manufacturable, usable, safe and reliable.
6) Verify that the product exhibits the characteristics necessary to prove effective and suitable during operational evaluation throughout the development phase.
7) Challenge the design and related processes for optimization.
8) Communicate requirements, design concepts and descriptions to other departments.

g) **Close out the review after (1) minutes have been prepared, approved, and distributed; (2) action items have been resolved; and (3) the review has been signed-off by the director**. Prepare the Technical Review Report.

Outputs
All outputs should be archived (SP 12)
- Technical Review Report (TRR) (SP 10)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agent.

Next Processes
Assessment Process
Sub-process 10: Progress Against Requirements
Control Process
Sub-process 12: Outcomes Management

Agents
Acquirer
Stakeholders
Program Management
Systems Engineering
Logistics

Tools
Requirements Management & System Architecture Database (ex. CORE™, DOORS, SLATE™)

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

MIL-STD-1521
DRAFT **MIL-STD-499B**
DoD 4245.7-M Transition from Development to Production Chapter 3
NAVSO P-6071 Best Practices Section 4.0

NAVAIR Specific:

- **NAVAIRINST 4355.19B** Systems Engineering Technical Review Process
- **NAVAIR Design Review Handbook (AIR 4.1)**

Metrics and Measures
Minutes and action items completed and accepted by the appropriate agent
Functional Allocation
Performance
Cost, Schedule, Weight
Risk

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completion of this sub-process (1) help ensure that all event-based plan criteria have been met, (2) provide ongoing status of design maturity and how well the concepts satisfy requirements, (3) provide traceability of requirements and validity of assumptions and decision rationale, (4) provide identification of issues to be resolved and those issues not determined during the development effort, and (5) highlight related risks, needed resources, and preparation for conducting the next engineering life-cycle-phase development effort.

4.2.3 Control Process

The Control Process is used to: (1) manage the conduct and outcomes of the Acquisition and Supply Processes, System Design Processes, Planning and Assessment Processes, Product Realization Processes, and Technical Evaluation Processes; (2) monitor variation from the plan and anomalies relative to requirements; (3) distribute required and requested information; and (4) ensure necessary communications. This process supports satisfaction of the agreement and assurance that variations and anomalies are corrected by repeating appropriate tasks.

The two sub-processes associated with the Control Process are shown in Figure 4.2.3.

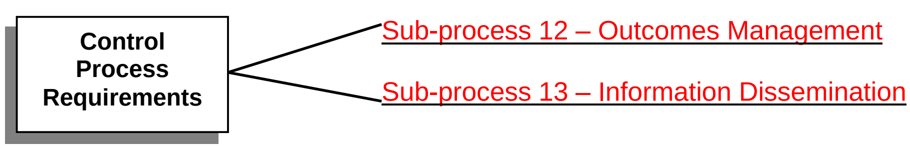


Figure 4.2.3 – Control Process/Sub-processes

Inputs to the Control Process are in the form of outcomes from other processes plus project and enterprise information affecting the engineering of a system.

Sub-process 12 – Outcomes Management

The developer **shall** manage the outcomes of the technical effort.

Preceding Processes

All other Systems Engineering Processes (Sub-processes 1-11, 13-33)

Inputs

Below is a generalized list of information that should be included in the Enterprise Data Repository. This is not an all-inclusive list. It should include all outputs of all Systems Engineering Processes (Sub-processes 1 through 33) as appropriate, even source documentation for creating items in the below list should be included for historical records.

- Mission Areas (Navy Mission Essential Task List (NMETL), Mission Capability Packages (MCPs), Joint Task Lists (JTLs), etc.)
- Solicitations
- Proposals
- Signed agreements
- Program plans
- Technical plans
- Changes
- Stakeholder information (e.g., doctrine, organization, training, material, leadership and education, people, and facilities (DOTMLPF))
- Reference documents
- Policies, methods, and procedures
- Technical Data Packages
- Metrics
- Cost objectives/information
- Work Breakdown Structure
- Schedules
- Life Cycle Support Plans
- Program Operating Guides (NAVAIR unique)
- Analyses
- Reports
- Technical presentations
- Requirements
- Traceability matrix
- Trade studies
- Functional and physical baselines
- Certifications
- Specifications
- Systems Engineering Plan
- Deficiencies and discrepancies

Entry Criteria

Inputs have been reviewed and approved by the appropriate agent.

Tasks

Outcomes management provides for the capture and management of data from the management and technical effort for the program. This information is used to redirect the work effort to overcome obstacles, to respond to changing circumstances, or to correct variances. An Enterprise Data Repository that was established in Sub-process 5 is used to preserve all the program's pertinent information that is needed by any and all of the program stakeholders.

The developer **should** plan to do appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Capture the outcomes, descriptions of methods and tools used, decisions and assumptions, lessons learned, and other data that allow for tracking requirements**.

An enterprise data repository should be used to store all information (doctrine, organization, training, material, leadership and education, people, and facilities (DOTMLPF)) and the engineering decisions used and generated describing the current state of the system. The enterprise process model and database should implement a traceability matrix that maps requirements to missions, to task and operational activivties, to system functions, and then on to systems. The result of this knowledge trace should provide a clear picture of the enterprise information capabilities and shortfalls, including the inherent associated costs for providing those capabilities.

The database should be a Core Architecture Data Model (CADM) or CADM compiliance repository. It should be shareable (collaborative enviroment) so that team members have access to the data/information needed in a native environment, to ensure persistent and correct data. The integrated and federated database must be accurate, collaborative, extensible, interactive, scalable, web enabled, unambiguous, secure, survivable, easily accessible by authorized users, and complete. The project should regularly back up the database using appropriate media to enable recovery from disaster, failure of equipment or media, or accidental deletion of data.

The following is usually recorded in the information database: (1) the outputs of the technical processes, including results from assessments; descriptions of methods, tools, and metrics used; and recommendations, decisions, assumptions, and impact of work and decisions; (2) lessons learned; (3) deviation from plan; (4) anomalies and out-of-tolerances relative to requirements; (5) other data that allow for tracking requirements; and (6) doctrine, organization, training, material, leadership and education, people, and facilities (DOTMLPF).

The front end of the enterprise database should be the architecture framework and framework/ environment upon which a systems engineering process will ride. The products of a framework, including activity diagrams, state transition, rules, event trace, etc., are all the front end equivalents of the functional flow and data flow models of the systems engineering process extended to the operational view of the enterprise. Further, the system interface diagrams, physical diagrams, information exchange requirements, etc., are all instances of the systems design side of the systems engineering process. These concepts further extend into the areas of performance, schedule, risk, budget, and modeling and simulation. Capturing decisions, assessments and rationale in architecture products is important for a number of reasons: it gives a context to requirements and specifications; it is useful when assessing the impact of downstream requirements changes; it captures hidden assumptions; and it acts as a requirement filter. Capture of rationale with each requirement often helps uncover the actual need that the statement of the requirement intended to identify.

b) **Perform configuration management** in accordance with the Configuration Management Plan. In doing this activity, the following tasks should be considered in accordance with the Configuration Management Plan (**Sub-process 7**).

1) Identify documents comprising the configuration baselines for the system and lower level items, and put them under configuration control.

2) Control of all proposed changes to the established configuration documentation.

3) Maintain and report information as to the disposition and implementation of change actions and as to current configuration status to appropriate stakeholders.

4) Perform audits, including verification that the system elements conform to the current approved specified requirements and documentation.

c) **Perform change management** in accordance with the change management plan. In doing this activity, the following tasks should be considered in accordance with the Change Management Plan (**Sub-process 7**)

1) Establish formal procedures for the initiation, assessment, review, approval, and disposition of changes to agreements and approved project requirement baselines, configuration baselines, plans, and work directives.

2) Identify and track proposed and directed changes to agreements and approved project requirements, configuration baselines, plans, work directives, or any other action or activity that would affect the outcome of the project.

3) Analyze each change to determine the impact to the system, the system product, and the remaining requirements.

4) Analyze the cost, schedule, performance and risks associated with making a proposed or directed change within schedule and resource availability.

5) Maintain and control traceability of changes including sources of the change, processing methods, and approvals in accordance with the Change Management Plan.

6) Disseminate the approved change information/data for implementation.

7) Update the agreement appropriately in all cases where a negotiated and approved change proposal affects the conditions of the agreement.

d) **Perform interface management** in accordance with the interface management plan. In doing this activity, the following tasks should be considered in accordance with the interface management plan (**Sub-process 7**)

1) Identify internal and external physical and functional interfaces that exist between products, functions, and tasks that are defined from other process activities (e.g., agreement, specification, system product tree, WBS, building block hierarchy).

2) Establish interface management responsibilities for those interfaces that are part of the agreement boundaries.

3) Maintain and control identified internal and external physical and functional interfaces including completion of interface definitions, assessments of compatibility, changes, and coordination and approvals with appropriate stakeholders.

4) Prepare and maintain appropriate physical and functional interface specifications or interface control documents/drawings to describe and control interfaces external to the system products, interfaces between system elements, and interfaces among configuration management items in accordance with the Interface Management Plan and project directives or procedures.

5) Establish and implement formal change procedures for interface evolution.

6) Disseminate the needed interface information/data for implementation and control.

e) **Perform risk management** in accordance with the Risk Management Plan. Risk analysis is performed in **Sub-process 24** but is managed in this sub-process. Both are done in accordance with the Risk Management Plan as developed in **Sub-process 7**.

f) **Perform data and document management** in accordance with the data and document management plan. In doing this activity, the following tasks should be considered in accordance with the data and document management plan (**Sub-process 7**).

1) Capture and organize inputs as well as current, intermediate, and final outputs.

2) Provide data correlation and traceability among requirements, designs, solution, decisions, and rationale.

3) Be responsive to established configuration management procedures.

4) Function as a reference and support tool for the systems engineering effort.

5) Make data available and shareable as called out in the contract or with other agreements.

g) **Manage the information database** to ensure that captured data is properly retained, is secure, and is available to those with authority to have access.

Managing the information database includes setting up appropriate databases and procedures for capturing and retaining design data and schema, tools, and models. Data pertinent to the technical effort are readily accessible and should be maintained throughout the system life cycle. Safeguards are implemented to ensure data integrity and security and to prevent inadvertent loss or modification of data. The program has the responsibility to assure that the data is collected, stored, controlled, and available for proper configuration management of the evolving product design, specifications, and baseline. All data products should be received, logged, archived, recovered, transmitted, and distributed as required. In doing this activity, the following tasks should be considered:

1) Review data management activities periodically to confirm that the program data requirements are still valid.

2) Ensure that the process for review, approval and release of data is well understood through the program.

3) Establish the capability to retrieve desired program data quickly.

4) Archive data efficiently based upon common characteristics (e.g., key word, topics, contract number, etc.).

h) **Manage and track stakeholder requirements, system technical requirements, logical solution representations, physical solution representations, derived technical requirements, specified requirements, approved changes, and validation results**.

In systems with long development cycles, requirements can change significantly during the development period. As the system development progresses, both users and developers become more knowledgeable about both the requirements and the system. This inevitably leads to changes in the requirements. If the proposed changes are ignored, the delivered system will fail to satisfy the users' needs. If the proposed changes are accepted, cost overruns and delays usually accompany the requirement changes. In most developments, the decision is made to "freeze" requirements as early as possible, often resulting in systems that fail to meet users' needs. Recognizing that requirements change in nearly every system development, the problem becomes one of managing the changes in an efficient manner. These circumstances include changes in the external environment, a better understanding of users' needs, or a better understanding of development success and failures. As in traditional system development models, the team must balance performance, cost, and schedule factors when making decisions about the acceptance of new requirements, as well as removal of previously baselined requirements that have been overcome by events. The project team uses the Outcomes Management process as a basis for making prudent development decisions. In the event that the

membership of the team has changed significantly since the development of the original requirements, a likely scenario in systems with long development timelines, the team has at its disposal both the decisions and rationale that were previously captured. When the requirements baseline is modified, the rationale associated with each existing or new requirement is also modified, thereby providing traceability and history. As the system matures in its development lifecycle, it is expected that both the magnitude and number of changes will decrease.

There are software programs designed specifically to assist in the management and tracking of the systems engineering process such as DOORS, CORE™, SLATE™, and Rational Rose. It is strongly encouraged that these are evaluated for appropriateness to the project and used whenever feasible.

Outputs
- Program Information (SP 13)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agent.

Next Processes
Control Process
Sub-process 13: Information Dissemination

Agents
Program Manager (PM)
Systems Engineering

Tools
Requirements Management & System Architecture Database (ex. CORE™, DOORS, SLATE™)

References
Standard across all systems engineering efforts:
- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

Metrics and Measures
Information is accurate and available in a timely manner as defined by the program.

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process help to ensure that the outcomes of the applicable processes for engineering a system are properly recorded and managed according to the applicable plan, the agreement, or enterprise policies and procedures.

Sub-process 13 – Information Dissemination

The developer **shall** ensure that required and requested information is disseminated in accordance with the agreement, project plans, enterprise policies, and enterprise procedures.

The purpose of this sub-process is to ensure that required and requested information is properly disseminated so that necessary communications within the project and enterprise, and with the customer and other stakeholder community, are efficiently and effectively completed throughout the system life cycle. Project risks are

increased when information is not available for decision-making in a timely manner or if the information provided is of insufficient quality (e.g., too much, incomplete, not relevant, or inaccurate).

Preceding Process
Information requests could come from any of the other 32 sub-processes.

Inputs

- Program Information (SP 12)
  - Enterprise Data Repository (information database) that consists of recorded outputs from sub-processes 1 through 12 and 14 through 33.
- Requests for information (SP All) used, in conjunction with Sub-process 12 and the information from all other sub-processes, to determine the kinds of information to capture in the Enterprise Data Repository Repository or information database, such as the following:
  - Supplier workforce capability, resource availability and other legal, regulatory, enterprise and project bounds to determine capability to meet acquisition request requirements. (Sub-process 1)
  - Acquirer legal, regulatory, enterprise and project bounds affecting establishment of an agreement. (Sub-process 2)
  - Requirement or operational concept changes that might affect supplier's project. (Sub-process 3)
  - External and internal legal, regulatory, or directive documents that could affect the project. (Sub-process 4)
  - Project requirements. (Sub-process 5)
  - Key events, related tasks, and relevant completion criteria for the applicable enterprise-based life-cycle phase. (Sub-project 6)
  - Previously completed and approved technical plans. (Sub-process 7)
  - Work to be done, resource sources, schedules, budgets, and reporting requirements. (Sub-process 8)
  - Planned process metrics. (Sub-process 9)
  - Planned product metrics. (Sub-process 10)
  - Technical Review Plan, effectiveness analyses outcomes, risk analyses outcomes, and trade-off analyses outcomes and assumptions. (Sub-process 11)
  - Technical plans, as applicable, for configuration management, change management, interface management, risk management, and data and document management. (Sub-process 12)
  - Acquirer and other stakeholder requirements. (Sub-process 14 and 15)
  - System Technical Requirements. (Sub-process 16)
  - Logical solution representations derived technical requirements, and system technical requirements. (Sub-process 17)
  - Selected physical solution representation and associated derived and system technical requirements. (Sub-process 18)
  - Design solution work products including specified requirements and acquirer input requirements. (Sub-process 19)
  - Enabling product, shipping and storage, site preparations, installation, acceptance and certification testing, training and in-service support requirements, as appropriate to agreement. (Sub-process 21)
  - Effectiveness analyses and risk analyses outcomes. (Sub-process 22)
  - Characterization of solutions to be analyzed. (Sub-process 23)
  - Acceptable levels of risk to the project. (Sub-process 24)
  - Requirements from Sub-processes 16, 17, 18 and 19. (Sub-process 25)
  - Acquirer requirements sources (inputs to Sub-process 14) and set of defined acquirer requirements (outputs of Sub-process 14).
  - Other stakeholder sources (inputs to Sub-process 15) and the set of defined other stakeholder requirements (output of Sub-process 15).
  - Stakeholder requirements (inputs to Sub-process 16) and the set of defined system technical requirements (outputs from Sub-process 16).
  - System technical requirements (inputs to Sub-process 17) and sets of logical solution representations and derived technical requirements (outputs of Sub-process 17).
  - Requirements for the selected physical solution representation (inputs to Sub-process 19) and the physical solution specified requirements (outputs from Sub-process 19).
  - Physical solution working products including specified requirements (outputs of Sub-process 19).

- Requirements for enabling products (output of Sub-process 19).
- Acquirer requirements (output from Sub-process 14).
- Trade-off analysis/Analysis of Alternatives recommendations, impacts and assumptions (outputs of Sub-process 23).

Entry Criteria

Inputs have been reviewed and approved by appropriate agents.
The information requested from the Enterprise Data Repository (information database) are certified as being up-to-date, accurate, reliable, and releasable by an appropriate agent.

Tasks

The developer **should** plan and do the appropriate tasks to complete this sub-process. Information to consider for dissemination includes, as appropriate, the materials captured and controlled in the information database. Tasks to consider include a) though j) in the following, and tasks to complete include k) through s):

a) **Provide technical progress status**:

Architecture products as defined in the C4ISR Architecture Framework and Joint Technical Architecture (JTA).

Process and product metric data resulting from Sub-processes 9 and 10 should be disseminated to meet approved requests and as specified in:

- Project agreements (Sub-processes 1 and 2) and task assignments (Sub-process 8).
- Project plans, especially project technical plans such as the SEP or engineering plan (Sub-process 7).
- Enterprise policies and procedures.

b) **Provide technical planning information**.

Appropriate technical plans and work packages (Sub-processes 7 and 8) should be disseminated to project teams and other required or approved recipients.

c) **Disseminate approved and controlled requirements**.

Acquirer, other stakeholder, system technical and derived technical requirements, and all changes to requirements, (Sub-process 14, 15, 16, 17, 18, 19 and 12) should be distributed in a timely manner to all stakeholders to ensure that all work is conducted in accordance with the latest approved requirements.

Two types of output specified requirements are Performance Specifications and Detail Specifications. These requirements are used for realizing the end product and are allocated to subsystems of the end product for developing lower level building blocks. As descriptions of the end product solution, they are also used for product verification (Sub-process 31).

- Performance specifications are used when it is appropriate to state requirements in terms of: (1) the required results without stating the method for achieving the required results; (2) function (what is to be accomplished) and performance (how well each function is to be performed); (3) the environment in which the product(s) must perform these functions; (4) the interface and interchangeability characteristics; and (5) the means for verifying compliance.

- Detail specifications are used when it is appropriate to state design requirements in terms of: (1) material to be used; (2) how a requirement is to be achieved; and (3) how a product is to be fabricated or constructed.

d) **Provide information for, and from, technical reviews**.

As appropriate, the following (Sub-process 11) should be disseminated to approved recipients and as specified in the agreement, technical review plan, and enterprise policies and procedures:

- Read-ahead technical review package to technical review board members.
- Information and items necessary to demonstrate that event-based criteria have been satisfied for initiation of the review.
- Information packages and presentation materials at the review.
- Minutes of the review.
- Action items required for closure.
- Final review closeout approval.
- Technical Review Report

e) **Make available design data and schema**.

Data pertinent for the technical effort (Sub-processes 17, 18 and 19) should be disseminated to project teams and team members to ensure information availability for decisions and events and to other authorized recipients requesting information.

Design data and schema information should include, as appropriate, source, version, and distribution information for documents used in the engineering or reengineering of system products and services including system product technical data packages. The technical data package should consist of, as appropriate: a buy-to description (e.g., detail specifications and/or final drawings); a build-to description (models, final drawings, and detail or performance specifications depending on the maintenance concept, production plan, tool design, bill of materials, and statistical process control plan); design documentation; engineering changes, deviations, and waivers; and enabling product descriptions.

f) **Make available lessons learned**.

Lessons learned from applicable sub-process implementation that have been recorded in the Enterprise Data Repository, or other lessons learned document, should be disseminated to other projects within the enterprise, to other teams within the project, and to project suppliers as appropriate.

g) **Report variances**.

Product and process variances and anomalies (Sub-processes 9 and 10, and 25 through 33 (progress assessments, validations and verifications)) should be reported along with:

- Recommended actions to return the product or process metric to established expectations or requirements.
- Cost and schedule impacts.
- Effect on the project if action is not taken.

h) **Disseminate data deliverables**.

Data deliverables generated by project sub-processes should be disseminated as required by the agreement, enterprise policies and procedures, and project plans including the engineering plan.

i) **Disseminate approved changes**.

Approved requirements and design changes (Sub-process 12) and updated plans (Sub-processes 5, 6 and 7) should be distributed to approved or required recipients.

j) **Disseminate directives**.

Work directives resulting from management decisions (Sub-processes 11 and 12), planning (Sub-processes 4 through 8), and approved changes (Sub-process 12) should be disseminated to intended

recipients that will initiate or change work by project teams or support organizations within the enterprise.

In addition to the tasks, the following tasks should be completed:

k) Establish a framework for information flow within the project including the language(s) to be employed in project information exchanges.

l) Maintain an information library or reference index to provide information available and access instructions.

   Access information should include means of access, access security passwords, time period information will be available, and personnel cleared for access. This is to allow direct access to the Enterprise Data Repository for those persons with access authority and who have the technology available to enable access.

m) Identify and document the data delivery requirements found in the agreement, project plans and enterprise policies and procedures.

   Requirements include information desired, when required, scope of information to be made available, security and special handling, metrics, summaries, change control, traceability, and delivery instructions.

n) Establish a handling, approval and disposition procedure for identified data deliverables.

o) Establish, as appropriate, a data/information request form and a handling, approval, and disposition procedure for special requests for project information.

p) Assign appropriate responsibilities and authorities to persons or groups for the handling, approval and disposition of received information requests and identified data deliverables from the agreement, project plans, and enterprise policies and procedures.

   Persons and groups assigned responsibility and authority to disseminate data and information should be informed of their obligations and responsibilities, especially with respect to information and data legislation, security, privacy, ownership, agreement restrictions, rights of access, intellectual property, copyrights, and patents.

q) Set up a data delivery system to control what has to be delivered, when it has to be delivered, the format of the data to be delivered, the medium in which the data is to be delivered, delivery status, and any other peculiar handling, storage or classification of the data required.

   Information may originate and may terminate in any form (e.g., verbal, textual, graphical, numerical) and may be stored, processed, replicated, and transmitted using any medium (e.g., electrical, printed, magnetic, or optical).

   Relevant information storage, transformation, transmission and presentation standards and conventions should be used according to agreements, legislation constraints, and enterprise policy.

   The status of information items disseminated (e.g., version description, record of distribution, security classification, recipient, authority for dissemination, end product approving agent) should be recorded.

r) Evaluate the information system to identify generation and recording of performance issues and problems; application of information in the current system life-cycle stage; satisfaction of information users; risks associated with delayed or corrupted information, unauthorized access, or survivability of information from hazards such as fire, flood, earthquake, etc.; and recommend improvements.

Evaluation should include: (1) proof of correctness, accessibility, availability, reliability, and security of data/information provided to internal and external recipients; and (2) proof of coherence of the overall project information set to facilitate effective and efficient use of the information both during and after the project.

s) Assure that required and requested information is appropriately distributed to satisfy the needs of the acquirer and requesters in accordance with the agreement, project directives and plans, and enterprise policies and procedures.

Outputs

All outputs should be archived (SP 12)

- Completed request for information forms (SP 12)
- Status of Information dissemination (SP 12)
- Program information (SP All) to be delivered to the requesting sub-process as required by the agreement, project plans including the engineering plan (SEP), and enterprise policies and procedures, as well as required by appropriately approved requests. Example outputs include:
  - Agreements
  - Directives to do work (e.g., task assignments, and work authorizations)
  - Information for doing work (e.g., agreement tasks; requirements; schedules; budget allocations; product interfaces – physical, data, human, functional; and work interfaces – other teams, other projects, other organizations)
  - Explanations for work done (e.g., rationale for design decisions)
  - Recommendations including assumptions made with respect to trade-off analyses
  - Sources of information (e.g., websites, standards, or directives)
  - Best practices used in the technical work of the project (e.g., tools, and methods)
  - Status information (e.g., progress, issues, risks, variations and actions being taken with expected results)
  - Cost, schedule and performance constraints and thresholds
  - WBS information
  - IMS (Integrated Master Schedule)
  - IMP (Integrated Master Plan)
  - Enabling product information (e.g., requirements for development or for acquisition of existing enabling products)
  - Approved changes

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents.

- Recipients are authorized to have the information and have the proper security clearances to receive the information when it is classified.
- Information is properly packaged, handled, shipped/transmitted, and controlled as appropriate to the classification and sensitivity of the material being disseminated.

Next Processes

Sub-process(es) corresponding to the requested information.

Agents

Information Specialist
Data and Document Manager
Systems Engineering
Acquirer
Supplier

Tools

Microsoft Word
Excel Spreadsheet

Enterprise Data Repository

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**

Capability Maturity Model® Integration (CMMI℠), 2001: Organizational Environment For Integration process areas
Security control directives for the handling, packaging and transmittal of classified information

Metrics and Measures
Percent of on-time deliveries of information requested.
Percent of on-time deliveries of information required.
Number of complaints on the quality of disseminated information.
Number of security violations for improper handling, storage, and transmittal of classified materials.

The expected outcomes for the representative tasks associated with this distribution are provided in **Appendix C**. The outcomes associated with completing this sub-process help to ensure that the required and requested information is appropriately distributed to satisfy the needs of the acquirer and requesters, in accordance with an agreement, project directives and plans, and enterprise policies and procedures.

4.3 System Design

The System Design Processes are used to convert agreed-upon requirements of the acquirer into a set of realizable products that satisfy acquirer and other stakeholder requirements.

Two processes are involved – Requirements Definition and Solution Definition. The relationship of these processes is shown in Figure 4.3a.

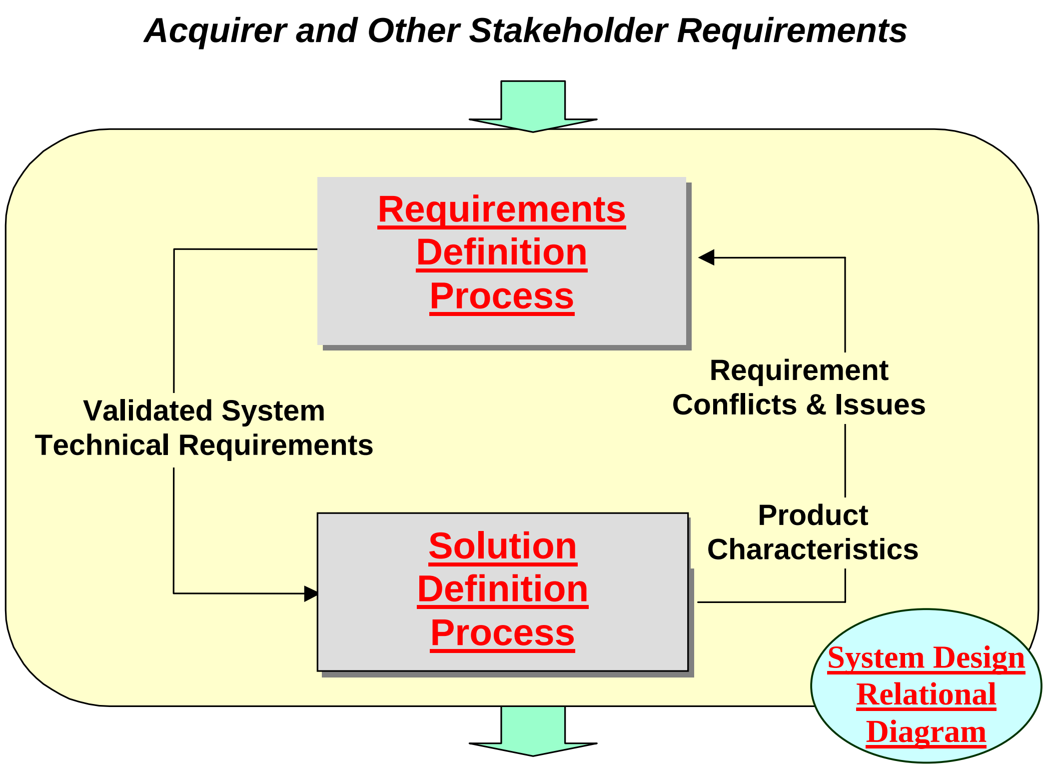


Figure 4.3a – System Design Process

The systems design process is a top-down comprehensive, iterative and recursive problem solving process applied sequentially through all **Life Cycle Phases and Stages of Development** as shown in Figure 4.3b, which is from DoD5000 Instructional Information:

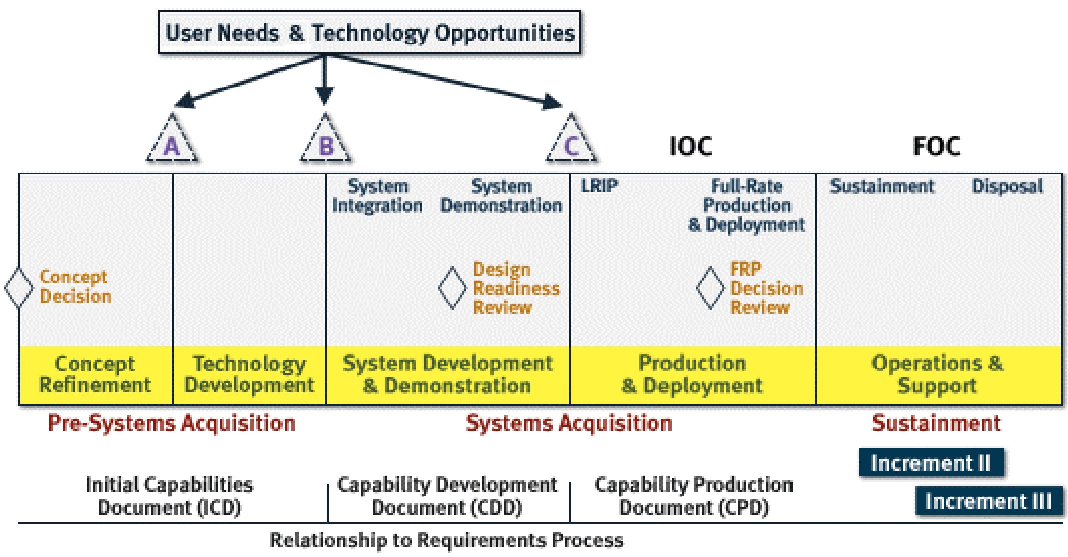


Figure 4.3b – System Design Process

During the Stages of Development**,** the iterative process is used to:

- transform needs and derived requirements into a set of system product and process descriptions (adding value and more detail with each level of development);
- generate information for decision makers; and
- provide input for the next level of development.

As illustrated by the **System Design Relational Diagram**, the fundamental systems design activities are: Acquirer and Stakeholder Requirements Definition, System Technical Requirements Definition, Logical Solutions Representation (Functional Analysis and Allocation), Physical Solution Representation (Design Synthesis), and Specified Requirements Definition; all balanced by other processes within this Guide called Assessment, Control, and System Analysis. These processes are used to make decisions and track requirements, maintain technical baselines, manage interfaces, identify and manage risks, track cost and schedule, track technical performance, verify requirements are met, and review/audit the progress.

During system design iteration, derived requirements and architectures are generated to better describe and understand the system. The word "architecture" is used in various contexts in the general field of engineering. It is used as a general description of how the sub-systems join together to form the system. It can also be a detailed description of an aspect of a system: for example, the operational, system, and technical architectures used in hardware and software intensive developments. However, systems engineering management, as developed in DoD, recognizes three universally usable architectures that describe important aspects of the system: functional, physical, and system architectures.

The *functional architecture* identifies and structures the allocated functional and performance requirements. The *physical architecture* depicts the system product by showing how it is broken down into subsystems and components. The *system architecture* identifies all the products (including enabling products) that are necessary to support the system and, by implication, the processes necessary for: development, production/construction, deployment, operations, support, disposal, training, and verification.

Life Cycle Phase integration is achieved through integrated development – that is, concurrent consideration of all life cycle needs during the development process. DoD policy requires integrated development to be practiced at all levels in the acquisition chain of command as described in the Integrated Product and Process Development (IPPD) Handbook. Concurrent consideration of all life cycle needs can be greatly enhanced through the use of interdisciplinary teams. These teams are often referred to as Integrated Product Teams (IPT). The objective of an IPT is to:

- produce a design solution that satisfies initially defined requirements, and communicates that design solution clearly, effectively, and in a timely manner;
- place balanced emphasis on product and process development;
- assure early involvement of all disciplines appropriate to the team task; and
- achieve concurrent technical management.

Life-cycle-phase functions are the characteristic actions associated with the system life cycle. They are development, production and construction, deployment (fielding), operation, support, disposal, training, and verification. These activities cover the "cradle to grave" life cycle process. The customers of systems design perform the life cycle functions. The system user's needs are emphasized because their needs generate the requirement for the system, but it must be remembered that all of the life-cycle-phase functional areas generate requirements for the system design once the user has established the basic need. Those that perform these functions also provide life cycle representation in design-level integrated teams.

This technical effort begins with identifying, collecting, and defining *acquirer* and *other stakeholder requirements*. These requirements are transformed into a set of validated *system technical requirements*. The validated system technical requirements are then transformed into a design solution described by a set of *specified requirements*. The specified requirements take the form of specifications, drawings, models, or other design documents depending on design maturity. These are used to: (1) build, code, assemble and integrate end products; (2) verify end products against requirements; (3) obtain off-the-shelf products; or (4) assign to a

supplier the development of subsystem products. The relationship between the requirements involved with the System Design Processes is shown in Figure 4.3c.

> NOTE – Requirements traceability is instituted for tracking requirements from the identification of acquirer and other stakeholder requirements to the system technical requirements logical solution representations, physical solution representations, derived technical requirements, and specified requirements. (See **Sub-process 12**, task h).)

THIS PAGE INTENTIONALLY LEFT BLANK

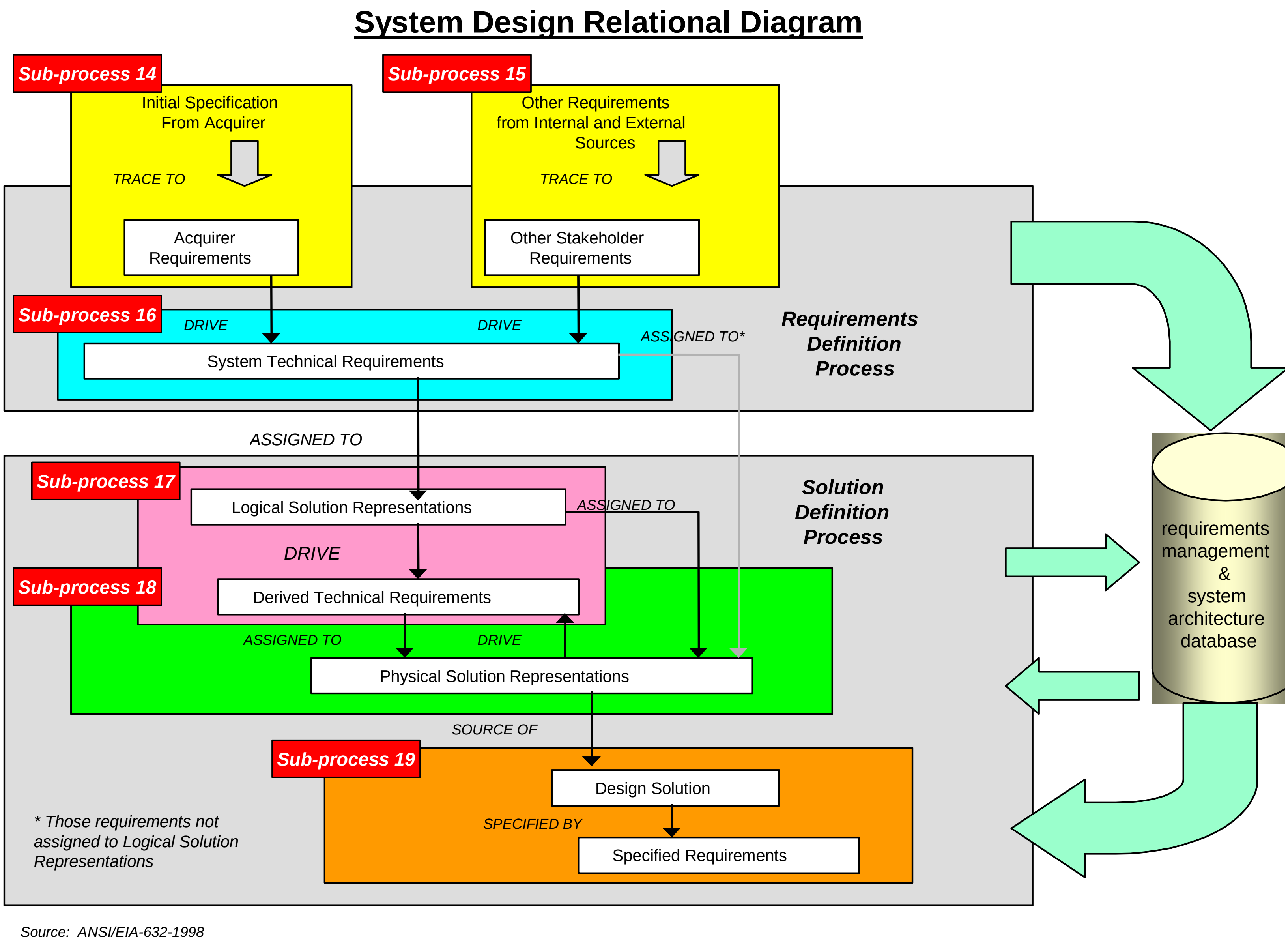


Figure 4.3c – System design relation diagram

4.3.1 Requirements Definition Process

The three sub-processes associated with the Requirements Definition Process are shown in Figure 4.3.1a.

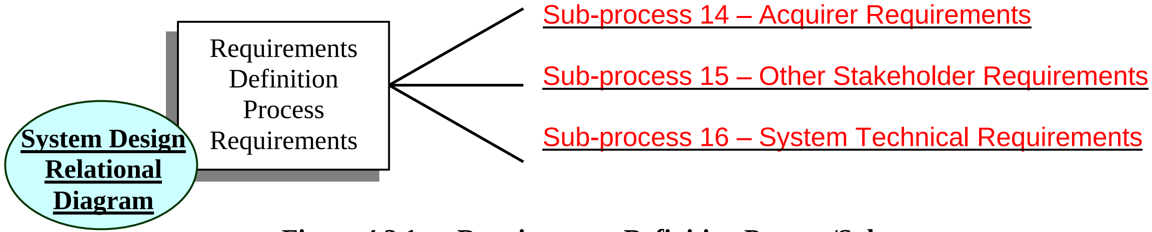


Figure 4.3.1a – Requirements Definition Process/Sub-processes

Inputs to the Requirements Definition Process are of three types: (1) requirements from the agreement, other documents, and individuals or groups that have a stake in the outcome of the engineering or reengineering of the system, (2) requirements in the form of outcomes from other processes such as technical plans and decisions from technical reviews, and (3) requested or approved changes to requirements of the first type.

The Department of Defense (DoD) inputs to this process are the Initial Capabilities Document (ICD) – formerly Mission Needs Statement (MNS), and Capability Development Document (CDD) – formerly Operational Requirements Document (ORD). These items are well defined for formal Acquisition Category (ACAT) programs but should be completed on an informal level for all programs. These should be reviewed for appropriateness repeatedly throughout this process as the product evolves.

NOTES

1 The requirements defined by this process come from stakeholders who have an interest in the system being engineered. Stakeholders are of two kinds: the acquirer of the system products (see the definition of acquirer in the Glossary, Appendix A) and all other stakeholders (see the definition of other stakeholders in Appendix A).

2 The Requirements Definition Process is used to transform stakeholder requirements into a set of system technical requirements. These requirements are stated in acceptable technical terms and represent a reasonably complete description of the problem that must be solved to provide a set of end products and enabling products that meet the acquirer's and other stakeholders' needs and expectations.

3 The Requirements Definition Process is re-accomplished, as necessary, whenever requirements in an agreement change or when other stakeholder requirements are identified that affect the product design or otherwise constrain the technical effort required to engineer a new system, develop a derivative system, or reengineer a legacy system. Such changes could be caused by technology limitations, project schedule and cost anomalies, or new requirements.

4 Sometimes it is important to preserve competition when defining requirements to ensure that there will be more than one supplier that can meet the requirements. Otherwise, the cost of a single supplier can be too high since there can sometimes be little incentive to give a low-cost bid.

Sub-process 14 – Acquirer Requirements

The developer **shall** define a validated set of acquirer requirements for the system, or portion thereof.

Preceding Processes

Systems Analysis Process
  Sub-process 22: Effectiveness Analysis
Requirements Validation Process
  Sub-process 26: Acquirer Requirements Validation

Inputs *("EXT" indicates it is external, unspecified, and not from a sub-process.)*

- Initial Capabilities Document (ICD) – formerly Mission Need Statement (MNS) (User, Fleet) (EXT)
- Capability Development Document (CDD) – formerly Operational Requirements Document (ORD) (OPNAV) (EXT)
- Engineering Investigation Reports (In-Service, Safety, Logistics, etc.) (User, Fleet) (EXT)
- Utilization and Readiness Reports (NALCOMIS) (EXT)
- Specifications from higher level system building blocks (EXT)
- Sponsor High-Level Operational Concept Graphic (OV-1) architecture (EXT)
- Effectiveness Analysis Reports (SP 22)
- Effectiveness Models (SP 22)
- Acquirer Requirements Validation Revisions (SP 26)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agent.

Tasks
The team **should** plan to do appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Identify, collect, and prioritize assigned, customer, user, or operator requirements for the system, or portion thereof, including any requirements for development, production, test, deployment/installation, training, operations, support/maintenance, and disposal of the system's products**.

   The expected input from the sponsor should include:
   - Initial Capabilities Document (ICD) – formerly Mission Need Statement (MNS)
   - Capability Development Document (CDD) – formerly Operational Requirements Document (ORD)
   - Program objectives
   - Mission Area Analysis (MAA) (**Sub-process 22: Effectiveness Analysis**)
   - Measures of Effectiveness (MOE) (**Sub-process 22: Effectiveness Analysis**)
   - High-Level Operational Concept Graphic (OV-1) architecture

   Although the sponsor typically provides these inputs, analyses and validation are required to ensure the team has a clear understanding of the customer requirements. In cases were these documents are not provided, the team shall perform appropriate modeling, simulation, and analysis to develop comparable requirements studies. These analyses include:
   - Surveying the sponsor, fleet operators, and maintainers
   - Mission analysis (**Sub-process 22: Effectiveness Analysis**)
   - System concept analysis (**Sub-process 22: Effectiveness Analysis**)
   - Operational concept analysis (**Sub-process 22: Effectiveness Analysis**)
   - Operational requirements analysis

b) **Ensure that the resulting set of requirements agrees with the acquirer needs and expectations** (see **Sub-process 26**).

c) **Record the resulting set of acquirer requirements in the established information database** (see **Sub-process 12**).

Outputs
All outputs should be archived (SP 12)

- Initial Capabilities Document (ICD) – formerly Mission Needs Statement (MNS) (SP 2, 4, 7, 10, 11, 16, 31, 33)
- Effectiveness Analysis Request (SP 22)
- Measures of Effectiveness (MOE) (SP 5, 7, 16)

- Capability Development Document (CDD) – formerly Operational Requirements Document (ORD) (SP 2, 4, 7, 10, 11, 16, 31, 33)
- Specifications from higher level system building blocks (SP 16)
- Acquirer requirements (SP 5, 16, 26)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents.

Next Processes
Acquisition Process
  Sub-process 2: Product Acquisition
Planning Process
  Sub-process 4: Process Implementation Strategy
  Sub-process 5: Technical Effort Definition
  Sub-process 7: Technical Plans
Assessment Process
  Sub-process 10: Progress Against Requirements
  Sub-process 11: Technical Reviews
Control Process
  Sub-process 12: Outcomes Management
Requirements Definition Process
  Sub-process 16: System Technical Requirements
Systems Analysis Process
  Sub-process 22: Effectiveness Analysis
Requirements Validation Process
  Sub-process 26: Acquirer Requirements Validation
System Verification Process
  Sub-process 31: End Product Verification
End Products Validation Process
  Sub-process 33: End Products Validation

Agents
Acquirer
User
Concepts Analysis
Cost Analysis
Fleet Project Team (FPT)
Operations (Ops) Analysis
R&M
Systems Engineering

Tools
Survey
Questionnaire
Quality Function Deployment (QFD) Capture
Modeling & Simulation (M&S)
Queuing Methodology (AWESim, SLAM)
Integrated Definition (IDEF)
Requirements Management & System Architecture Database (ex. CORE™, DOORS, SLATE™)

References
Standard across all systems engineering efforts:
- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**

- Defense Acquisition University: Systems Engineering Fundamentals
- INCOSE Systems Engineering Handbook
- C4ISR Architecture Framework
- Joint Technical Architecture

Systems Engineering & Analysis (Blanchard)
MIL-STD-498
Capability Maturity Model® Integration (CMMI[SM]), 2001: Requirements Development process areas

Metrics and Measures
Percent completion of analysis and output products.
Percent of acquirer requirements that have been validated.

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process are used, when combined with other stakeholder requirements, to define the system technical requirements, and to identify requirements for enabling products.

Sub-process 15 – Other Stakeholder Requirements

The developer shall define a validated set of other stakeholder requirements for the system, or portion thereof.

Preceding Process
Planning Process
Sub-process 4: Process Implementation Strategy
Sub-process 8: Work Directives
Systems Analysis Process
Sub-Process 22: Effectiveness Analysis
Requirements Validation Process
Sub-process 27: Other Stakeholder Requirements Validation

Inputs *("EXT" indicates it is external, unspecified, and not from a sub-process.)*
- List of stakeholders and roles (SP 4)
- Team Work Plan (TWP) (SP 8)
- Statement of Objectives (SOO) (SP 8)
- Statement of Work (SOW) (SP 8)
- Effectiveness Analysis Reports (SP 22)
- Effectiveness Models (SP 22)
- Other stakeholder requirements validation revisions (SP 27)
- DoD/Naval policy and directives (EXT)
- Federal/International Laws and regulation (EXT)
- International /National standards (EXT)
- Team / Project objectives, constraints, and policy (EXT)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agent.

Tasks
The developer **should** plan and do appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Identify and collect other stakeholder requirements that can constrain the system's end products**. Be sure to consider joint project stakeholders requirements.

b) **Identify and collect other stakeholder requirements that can constrain development, production, test, deployment/installation, training, support/maintenance, and disposal of the system products**.

c) **Identify and collect other stakeholder constraints such as applicable laws and regulations; technology base; standards and specifications; competitor's product capabilities and trends; and interfaces with other evolving systems or platforms**.

d) **Ensure that the resulting set of requirements agrees with other stakeholder needs and expectations** (see **Sub-process 27**).

e) **Record the resulting set of stakeholder requirements in the established information database** (see **Sub-process 12**).

Outputs

All outputs should be archived (SP 12)

- Effectiveness Analysis Request (SP 22)
- Other stakeholder requirements (SP 5, 16, 27), such as:
  - Project plans, Teams (possible Joint Team Projects), Organization, Automated tools metrics, Management decision criteria, Standards, Guides, Policies, Procedures, and Physical/financial resources
  - Manufacturing, Production, Test, Deployment, Installation, Training, Support, Disposal processes and capacities
  - National and international standards, Laws, Regulations, Environment, Technology base, Industry standards, General specifications, and Competitor capabilities
  - Interfaces with other systems and platforms

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents.

Next Processes

Planning Process
  Sub-process 5: Technical Effort Definition
Control Process
  Sub-process 12: Outcomes Management
Requirements Definition Process
  Sub-process 16: System Technical Requirements
Systems Analysis Process
  Sub-Process 22: Effectiveness Analysis
Requirements Validation Process
  Sub-process 27: Other Stakeholder Requirements Validation

Agents

Systems Engineering
Enterprise Management
Manufacturing
PM
PEO
Test & Evaluation
Logistics
Depot
Other Systems Commands (Syscoms)

Tools

Surveys

Questionnaire
Requirements Management & System Architecture Database (ex. CORE™, DOORS, SLATE™)

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

IPPD Handbook

Metrics and Measures
Percent completion of analysis and output products.
Percent of other stakeholder requirements that have been validated.

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with the completion of this sub-process help to ensure that the other stakeholder requirements reflect the interests of those who have a stake in the outcome of the project and, when combined with acquirer requirements, can be used to define system technical requirements and requirements for enabling products.

NOTES
1 In general, other stakeholder requirements place constraints on the system development, both on the resulting system and the processes for developing the system products.
2 Some sources of other stakeholder requirements include the agreement, owners of associated processes, external system interfaces, market research, government and industry regulations, international conventions and agreements, projects and enterprise directives, project and enterprise process constraints, lessons learned, and interviews.
3 It is usually not possible to meet all other stakeholder requirements for a particular system since various stakeholders (including the acquirer) have conflicting requirements relative to one another. Some of these requirements can be addressed in later versions of the system.
4 Constraints can result, for example, from treaties, laws, regulations, standards, culture, natural laws, or firm customer or user needs.
5 Constraints also apply to those characteristics necessary to interface with other existing systems.

Sub-process 16 – System Technical Requirements

The developer shall define a validated set of system technical requirements.

Preceding Process

Planning Process
- Sub-process 5: Technical Effort Definition

Requirements Definition Process
- Sub-process 14: Acquirer Requirements
- Sub-process 15: Other Stakeholder Requirements

Systems Analysis Process
- Sub-process 22: Effectiveness Analysis
- Sub-process 23: Trade-off Analysis

Requirements Validation Process
- Sub-process 25: Requirements Statements Validation
- Sub-process 28: System Technical Requirements Validation

Inputs *("EXT" indicates it is external, unspecified, and not from a sub-process.)*

- Sponsor High-Level Operational Concept Graphic (OV-1) architecture (EXT)
- Specifications from higher level system building blocks (SP 14)
- Initial Capabilities Document (ICD) – formerly Mission Needs Statement (MNS) (SP 14)
- Capability Development Document (CDD) – formerly Operational Requirements Document (ORD) (SP 14)
- Measures of Effectiveness (MOE) (SP 14)
- Acquirer requirements (SP 14)
- Other stakeholder requirements (SP 15)
- Effectiveness Analysis Report (SP 22)
- Effectiveness Models (SP 22)
- Trade-off Analysis Technical Report (SP 23)
- Requirement statements validation revisions (SP 25)
- System technical requirements validation revisions (SP 28)
- Technical Data Package (TDP) (SP 5)
- Technology Roadmap (SP 5)
- Life Cycle Support Plans (SP 5)
- Pre-Plan Product Improvement (P^3I) (SP 5)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents.

Tasks

Requirements analysis is a verification of the system requirements. This verification can be provided in a System Requirements Document (SRD) from a system-designer perspective. The intent is to verify the requirements provided, identify over-stated or unnecessary requirements, and to identify missing requirements. Analysis of the intended system operation as represented in the Operational Concept Document along with analysis of requirements provided in the Capability Development Document are the keys to identification of system-level requirements. The process leads to the generation of system-level technical requirements.

Prior analyses shall be reviewed and updated, refining mission and environment definitions to support system definition. Requirement analysis shall be conducted to derive functional, performance and other requirements that will guide system definition and implementation, and verify that customer needs will be satisfied. In conducting requirement analysis, the following tasks shall be performed:

- Assist in refining customer objectives and requirements. Provide a detailed description of operation, defining all external interfaces and system reaction to input over these interfaces (including mode transitions), driving timelines, and operating environments. Derive first-level functional and specialty requirements.
- Define initial performance objectives and refine them into requirements. Define performance aspects of all functional requirements as derived from system operation and mission timelines. Define MOPs, associate them with MOEs, and cite critical Technical Performance Measurements (TPMs).
- Flesh out the system description by defining operator involvement, design and technology constraints, function concurrency and translation into capacity requirements. Identify and define constraints that limit solutions (e.g., missions and utilization environments or adverse impacts on natural and human environments).
- Identify high-risk elements (potential show stoppers) in areas of cost, performance, and schedule. Challenge questionable and conflicting requirements.

Establishing a total set of system requirements is a complex, time-consuming task involving nearly all program areas in an interactive effort. It must be done early since it forms the basis for all design, manufacturing, test, operations, maintenance, and disposal efforts, and therefore determines the cost and schedule of the program.

The input and output summary tables define the expected input and output for each of the above tasks. Output consists of both requirements and design information. A database serves as the point of capture of both categories of information. System requirements can also be documented in the System/Subsystem Specification (**DI-IPSC-81431**), if the project warrants requirement documentation at this time.

The developer **should** plan and do appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Establish required transformation rules, priorities, inputs, outputs, states, modes, and configurations** that will influence and affect the other tasks for definition of system technical requirements by identifying and defining them, as appropriate to each system product.

   Review concept of operations and elaborate where necessary on describing system behavior, starting with outputs generated by external systems (modified as appropriate by passing through the natural system environment) which act as stimuli to the system, causing it to take specified actions and produce outputs which are absorbed by external systems. These single threads of behavior are traced from source document statements and cover every aspect of operational performance, including logistical modes of operation, operation under designated conditions, and behavior required when experiencing mutual interference with multi-object systems.

   Aggregation of these single threads of behavior is a more or less mechanical process depending on the level of sophistication of tool support supplied with the design decision database. When aggregated, the logical sum of these single threads of behavior represent a dynamic statement of what the system is required to do. In some cases, the word "scenario" is used to describe a single thread of behavior and in other cases it describes a superset of many single threads operating concurrently.

   In defining the requisite system behavior within the operating environment(s), transformation rules are important in characterizing a system. A transformation rule is anything that tells a product how to transform one or more inputs into one or more outputs (transform inputs to outputs), or change from one mode/state/configuration to another given certain conditions to be true (transform from state X to state Y, for example). For example:
   - given inputs A and B, produce output C (inputs/outputs)
   - do the above only when in XYZ mode (mode/state)
   - do the above only when in configuration LMN (configuration)
   - convert A to A-prime by using the JKL algorithm (transformation rule)
   - when both A and B received at same time, process A first (priority)

Basically the nature of these transformation rules will differ depending on the technology being used, type of product (hardware, software, facilities, etc.), or the standard methods and tools used in a particular industry or company.

Define the various modes of operation (embedded training capability, full operational, etc.) for the system products under development. The conditions (environmental, configuration, operational, etc.), which determine the modes of operation, are also defined (IEEE 1999, 6.1.12).

Identify all possible types of observable input and output events that can occur between the system and its interacting external systems. Record them as input and output events in the database including information to trace the reason for their existence to prevent dilution of originating requirements.

b) **Define operational requirements** to include operational profiles, and for each operational profile, the utilization environment, events to which system end products must respond, frequency of use, physical and functional interfaces, and system functional requirements (what system end products must accomplish).

At the beginning of the program, systems engineering is concerned primarily with operational requirements analysis – leading to the translation of user needs into a quantifiable set of performance requirements that can be translated into design requirements. These objectives are then quantified in broad terms, and basic functions are identified that could fulfill the need. The objective of operational requirement analysis is to identify and express technical requirements in measurable parameters that state user needs in appropriate terms to guide system concept development. Performing the mission analysis in a parametric manner ensures that an appropriate system sizing (of communication links, data processing throughput and capacity, number of computers and personnel, and facility space) can be performed. The context diagram serves as a useful tool to depict Input/Process/Output Requirements analysis. The total system engineering process is an iterative operation, constantly refining and identifying new requirements as the concept develops and additional details are defined.

Items 1) through 4) below define information that should be included for each operational profile:

1) The utilization environment and factors, natural or induced, that can affect end product performance.

   This task is to define the utilization environments for each of the operational scenarios. All environmental factors, natural or induced, which may affect system performance, should be identified and defined. Factors which ensure that the system minimizes the potential for human or machine errors or failures that cause injurious accidents or death, and impart minimal risk of death, injury, or acute chronic illness, disability, and/or reduced job performance of the humans who support the system life cycle, are identified. Specifically, weather conditions (e.g., rain, snow, sun, wind, ice, dust, and fog), temperature ranges, topologies (e.g., ocean, mountains, deserts, plains, and vegetation), biological (e.g., animal, insects, birds, and fungi), time (e.g., day, night, and dusk), induced (e.g., vibration, electromagnetic, acoustic, and chemical), or other environmental factors are defined for possible locations and conditions where the system may be operated. Effects on hardware, software, and humans should be assessed for impact on system performance and life cycle processes (IEEE 1999, 6.1.8).

   If the inputs/outputs are expected to be significantly affected by the environment between the system and the external systems, add concurrent functions to the context diagram to represent these transformations, and add input and output events to the database to account for the differences in event timing between when it is emitted to when it is received.

2) The events to which end products must respond.

   Define all external stimuli impinging on the system that elicits a response.

3) The physical and functional interfaces (e.g., mechanical, electrical, thermal, data, and procedural) including physical interactions (e.g., form and fit), system boundaries (what is controlled by the developer) and interactions (e.g., information flows and behaviors) of products or environments within developer control and those systems or environments outside system boundaries.

   Provide a detailed definition of each external interface to the system, typically documented in an Information Exchange Requirements (IER), Interface Requirements Document (IRD) and an Interface Control Document.

4) What system end products must be able to accomplish (functional requirements) to satisfy acquirer identified requirements. Includes factors such as producibility, testability, transportability, installability, operability, supportability, disposability, reliability, availability, maintainability, security, and safety.

   Functional requirements serve to translate operational needs into system capabilities. This is the first stage in a sequence of decompositions leading to design. The mission should be examined and characterized in measurable requirement categories such as: quantity, quality, coverage, timeliness, and availability. An example of typical measurables for various systems is shown in the Figure 4.3.1b. Actual systems will have many measurables under each attribute and additional attributes such as communications, command and control, security, etc.

MEASURABLE				
ATTRIBUTE	SURVEILLANCE SATELLITE	COMMUNICATION SATELLITE	SUBMARINE	AIRCRAFT
QUANTITY	Frames/Day, Sq Mi/Day	Throughput (BPS)	No. of Missiles Carried	Wt. of Bombs or Armaments (lb)
QUALITY	Resolution (Ft)	S/N or BER	Targeting Accuracy (ft)	Navigation Accuracy (ft)
COVERAGE	Latitude & Long. (deg)	Latitude & Long. (deg)	Range (mi)	Range (mi)
TIMELINESS	Revisit Time (hr), Proc/Del Time (sec)	Channel Availability on Demand (min)	Time to get on-station (hr)	Time to acquire target (sec)
AVAILABILITY	Launch Preparation Time (days)	Bandwidth Under Stressed Conditions (Hz)	Cruise Duration (days)	Flight Prep Time (min)

Figure 4.3.1b – Examples of system attributes and measurables

It is important to note that as a result of the system analysis and flowdown, top-level functional requirements usually become lower level performance requirements. For example:

a. System – Transmit collected data in real time to remote ground site
b. Segment – Provide wideband data link from spacecraft to relay
c. Element – Provide 10 MHz link at 17.0 GHz
d. Subsystem – Provide 10 MHz link at 17.0 GHz with 10 W effective radiated power for 20 minutes maximum per orbital revolution.

The top-level performance measures are used to derive lower-level subsystem requirements for configuring components. An example of this would be the conversion of the mission requirement for aircraft target detection size and range into dedicated power, pulse width, and timing stability which could then be used by the designer of the radar system in sizing the hardware. As the above example illustrates, the level of detail to be specified is driven by the system level being addressed.

The concept of allocation is a useful technique to setting top-level technical requirements, organizing decompositions, and controlling the subsequent implementation to ensure compliance. The most straightforward application of allocation is the direct apportioning of a value to its contributors. The resulting allocation for a specific area, such as pointing error, is usually referred to as a budget. The technical budget represents an apportionment of a performance parameter to several sources. This may be a top-down allocation, such as pointing error budget, or a bottom-up summation, such as an electrical power budget. Characteristics such as pointing error or electrical power distribution would normally become parameters for Technical Performance Measurement (TPM).

This will eventually result in the conversion from mission parameters (targets/sq. mi.) into parameters that the hardware and software designers can relate to (Effective Radiated Power, Pointer Error, etc.). Functional decomposition tools such as functional block diagrams, functional flow diagrams, time lines, and context diagrams are useful in developing requirements. Quality Function Deployment (QFD) is also useful, particularly where the "voice of the customer" is not clear. As requirements are derived, the analyses that led to their definition must be documented and placed into the database.

ENGINEERING SPECIALTY REQUIREMENTS:
Care must be exercised that the myriad of engineering specialty requirements and constraints are incorporated. Product Development Teams (PDTs) are a way of insuring that their requirements are incorporated into appropriate specifications.

Guidance recommendations for various technical specialties will vary depending upon the nature of the program. **Appendix G** lists engineering specialty references specific to those disciplines. The IPT is responsible for determining what technical support is required to achieve the technical objectives of the program.

- The Engineering Specialty Table **Appendix G** highlights the more common technical specialties and DoD source documents containing recommended procedures. Those procedures should be employed through the tailored application of the relevant standards and guides, adapted to specific program characteristics.
- The systems engineering process will allocate system requirements to establish clear technical requirements for each technical specialty in a contract concurrent manner to support the integrated system design. The systems engineering process will collectively analyze the design specifications, conduct trade-offs, balance total system requirements, and establish the final configuration.

c) **Define performance requirements** (how well each functional requirement must be accomplished), including identification of key performance parameters.

The following are defined: (1) the performance expectations for each functional requirement (how well the function must be accomplished); (2) the set of Measure of Performance (MOPs) made up of the functional and performance requirement combinations associated with each MOE; (3) the Key Performance Parameters (KPPs) selected from the MOPs that will be key indicators of end product or system performance, and if not met, that will cause the associated MOE to not be satisfied and will put the project in cost, schedule, or performance risk; and (4) functional and performance verification approach for each requirement statement.

Performance requirements shall be:

- derived based on customer provided Measures of Effectiveness (MOEs). When measures of effectiveness are not provided at the level of detail needed, the engineer shall develop and use a set of measures of effectiveness relating to customer missions; utilization environment(s); needs, requirements, and objectives; and design constraints;
- interactively developed across all identified functions based on system life cycle factors; and
- characterized in terms of the degree of certainty in their estimate, the degree of criticality to system success, and their relationship to other requirements (MIL-STD-499B).

Typical performance parameters include range, accuracy, response time, probability of detection, and probability of kill. To establish timing-related performance requirements, high-level function flows, bounded by driving timelines, are recommended. Detailed Functional Flow Block Diagrams (FFBDs) can then be applied, as defined in **Sub-process 17**.

Finally, add information to trace the function timing from user-defined performance requirements to confirm operational correctness or to expose dynamic inconsistencies. In the latter case, record inconsistencies in the design decision database to ensure eventual resolution.

d) **Analyze acquirer and other stakeholder requirements, and derived functional and performance requirements** to define human interface requirements, establish capacities and timing, define technology and product design constraints, define enabling product requirements, identify conflicts, and determine criteria for Trade-off analyses to resolve conflicts.

1) Define Human System Integration Effects – Define the operator roles, as applicable, and the human interface requirements (ergonomic limitations, workspace, eye movement, access, cultural background, natural and induced environmental constraints, work tasks, and time constraints) associated with functional and performance requirements on potential users, operators, installers, or recipients and handlers of system end products.

   Early inclusion of human interfaces in requirements definition assures a good user interface and a system that achieves the required performance by operators, control and maintenance personnel. The Engineering Specialty Table (**Appendix G**) cites DoD source documents containing recommended procedures.

2) Do the required concurrency capacities (e.g., memory, storage, and flows) of end products and timing of events, states, modes, and functions related to each operational profile.

   Ensure that concurrent functions are clearly depicted in a timeline analysis covering the entire system. A composite picture of total demand on the system (particularly 'worst case' scenarios) is essential. Add traceability information to the database to record what external systems stimulate the functions, traced from functional source requirements.

3) Determine any constraints that will influence or affect end product design (e.g., materials, special skills, and automated tools), required physical characteristics (e.g., size, color, texture, weight, and buoyancy), operator safety, system security, reuse requirements, standardization of end products, open system architecture, maintainer access, handling and storage, transportability, and other attributes of end products or design processes of which trade-offs cannot be made.

   Design constraints recognize inherent limitations on the sizing and capabilities of the system, its interfacing systems, and its operational and physical environment. These typically include power, weight, propellant, data throughput rates, memory, and other resources within the vehicle or which it processes. These resources must be properly managed to insure mission success.

   Design constraints are of paramount importance in the development of derivative systems. A derivative system is a system, which by mandate must retain major components of a prior system. For example, an aircraft may be modified to increase its range while retaining its fuselage or some other major components. The constraints must be firmly established: Which components must remain unmodified? What can be added? What can be modified? The key principle to be invoked in the development of derivative systems is that the requirements for the system as a whole must be achieved while conforming to the imposed constraints.

   Within this realm of system definition, Systems Engineering personnel may also withhold a margin to accommodate unforeseen problems. The margin is held at the system level. In communication links, typically a 3 dB system margin is maintained throughout the development phase. These allocations are analyzed by Engineering personnel to verify their achievability. As

the design progresses, the current status of the allocations is reviewed at the control board meetings. Care must be exercised that "margins-on-margins" are not overdone, resulting in too conservative (possibly too expensive) a design.

The following is a suggested approach for design constraint definitions:

- Identify from the input documents all design constraints placed on the program. This particularly includes compliance documents, such as previously approved specifications and baselines, standard end items, non-developmental items, and reverse requirements.
- Analyze the appropriate standards and lessons learned to derive requirements to be placed on the hardware and software CI design.
- Identify the cost goals allocated to the design.
- Define system interfaces with other systems, human and environments, and identify or resolve any constraints that they impose. Human interfaces include information displays and operation controls. Environmental interfaces include sensing devices.
- Define COTS or NDI CIs constraints from those identified in **Sub-process 5**.
- Document all derived requirements in specifications and insure that they are flowed down to the CI level.
- Insure that all related documents (operating procedures, etc.) observe the appropriate constraints.
- Review the design as it evolves to insure compliance with documented constraints.

4) Define technical requirements for enabling products associated with processes to develop, produce, test, deploy/install, operate, support/maintain, train, and retire/dispose of end products under development or being improved. Identify and resolve requirements that have questionable utility or have unacceptable risk of not being satisfied.

   The above analysis is usually directed at the mission or payload requirements and does not consider the total system requirements, which include communications, command and control, security, supportability, life expectancy, etc. It is necessary to expand the analysis to include supporting areas in order to obtain the total system requirements.

5) Identify conflicts among the requirements set.

   Identify all user requirements, which lead to conflicting technical requirements. These frequently arise when the performance in one area adversely affects performance in another.

6) Define the set of risk, cost, schedule, and performance criteria to be used in conducting trade-off analyses for conflict resolution.

NOTES
1 Developers are to ensure that residual risks from constraints are not significant to harm or otherwise prevent the system from performing its functions, create unacceptable costs, or price the system's end products out of competitiveness.
2 Analyses of system requirements can necessitate consideration of existing or possible physical solutions to ensure feasibility.

Cost trade studies are initiated in order to identify cost "drivers" or areas where resources can best be applied to achieve the maximum cost benefit. These studies should examine those performance parameters where small changes in the parameters produce significant changes in costs or risks, commonly known as cost sensitivity analysis. For example, sometimes a relatively small change in mean-time-to-repair (MTTR) or mean-time-between-failures (MTBF) results in large savings in operational costs. Significant cost and risk drivers, once identified, can greatly assist requirements conflict resolution. These studies also help to identify areas in which emphasis can be placed during the subsequent sub phases to obtain the maximum cost reduction.

e) **Identify and resolve requirements that have questionable utility or have unacceptable risk of not being satisfied**.

Examine any adverse consequences of incorporating requirements.

- Is unnecessary risk being introduced?
- Is the system cost within budget limitations?
- Is the technology ready for production?
- Are sufficient resources available for production and operation?
- Is the schedule realistic and achievable?

f) **Resolve identified conflicts between the requirements**, e.g., sets of acquirer requirements and other stakeholder requirements, and among these sets (see **Sub-process 23**).

The systems engineer does not perform mission analysis and requirements analysis as discrete sequential operations. Rather the analyses are performed concurrently with mission needs playing the dominant role. It is essential that the system engineer proceed in this manner to assure progression toward the most cost-effective solution to the mission need. Throughout this process, the systems engineer makes cost/requirements trade-offs. The significant or controversial ones are formally documented and presented to the customer for review. Following mission/requirements analysis, system functional analysis proceeds leading to candidate system design(s), which are evaluated in terms of performance, cost, and schedule. While this process ideally results in an optimum technical system, in actuality, limitations on cost, schedule, and risk place constraints on system design which result in selection of a preferred system from a number of candidates, rather than the optimum technical solution.

Where existing user requirements cannot be confirmed, trade studies should be performed to determine more appropriate requirements to achieve the best-balanced performance at minimum cost. Where critical resources (Weight, Power, Memory, Throughput, etc.) must be allocated, trade studies may be required to determine the proper allocation.

g) **Prepare a set of system technical requirement statements that are well formulated** in accordance with **Sub-process 25**.

Assess requirements as to degree of certainty of estimate, and place a "To Be Reviewed" (TBR) flag after any requirement that is not completely agreed upon, or a "To Be Determined" (TBD) flag where the value is unknown. Place a list of all TBD/TBR items with responsibilities and closure dates at the back of the specification.

Prioritize all requirements as to the criticality of mission success. Since resources on any program are limited, this identifies where the effort should be concentrated in refining, deriving, and flowing down requirements.

h) **Ensure that the set of system technical requirements is correct** in accordance with **Sub-process 28**. The system technical requirements are documented in a System Requirements Document (SRD), which is validated in accordance with **Sub-process 28**.

i) **Record the resulting set of system technical requirements in the established information database**.

The validated set of system technical requirements and associated assumptions is captured in the project's information database and maintained and controlled throughout the life of the project in accordance with the Outcomes Management **Sub-process 12**.

NOTE – Controlled maintenance of the system technical requirements in the information database allows for traceability, supports validation, and is essential for change management.

Outputs *(List of sub-processes where output is used may include the originating sub-process.)*
All outputs should be archived (SP 12)
- Utilization environment (SP 16)
- Verification approach (SP 16)
- Operational profiles (SP 16, 17)
- Physical and functional requirements (SP 16, 17)
- Mission Profiles (SP 16, 17)
- Cycle timelines (SP 16, 17)
- Measures of Performance (MOP) (SP 16, 17)
- Key Performance Parameter (KPP) (SP 10, 16, 17)
- Functional performance (SP 16, 17)
- Human interface requirements (SP 16, 17)
- Function concurrency / capacity (SP 16, 17)
- Technology constraints (SP 16, 18)
- Design constraints (SP 16, 18)
- Enabling products requirements (SP 16, 17)
- Conflicting requirements (SP 16, 17)
- Effectiveness Analysis Request (SP 22)
- Trade Options and Constraints (SP 23)
- System Requirements Document (SRD) (SP 11, 17)
- System technical requirements (SP 5, 6, 8, 11, 17, 25, 28, 30)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents.

Next Processes
Planning Process
    Sub-process 5: Technical Effort Definition
    Sub-process 6: Schedule and Organization
    Sub-process 8: Work Directives
Assessment Process
    Sub-process 10: Progress Against Requirements
    Sub-process 11: Technical Reviews
Control Process
    Sub-process 12: Outcomes Management
Solution Definition Process
    Sub-process 17: Logical Solution Representations
    Sub-process 18: Physical Solution Representations
Systems Analysis Process
    Sub-process 22: Effectiveness Analysis
    Sub-process 23: Trade-off Analysis
Requirements Validation Process
    Sub-process 25: Requirements Statements Validation
    Sub-process 28: System Technical Requirements Validation
System Verification Process
    Sub-process 30: Design Solution Verification

Agents
Logistics, Ops Analysis, Systems Engineering, Test, Specialty Engineering, User

Tools
Functional Flow Block Diagram (FFBD), Quality Function Deployment (QFD), Context Diagram, Timeline Analysis

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

IEEE 1220
MIL-STD-499B
System/Subsystem Specification (SSS) Data Item Description (DI-IPSC-81431)
World Class Example, Jerry Lake, 1999.

Metrics and Measures
Percent completion of analysis and output products.
Percent of system technical requirements that have been validated.

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process provide a set of system technical requirements that are unambiguous, complete, consistent, achievable, verifiable, and necessary and sufficient for a system design.

4.3.2 Solution Definition Process

The Solution Definition Process is used to generate an acceptable design solution. This solution satisfies: (1) the system technical requirements resulting from completing the Requirements Definition Process described in Subsection 4.3.1; and (2) the derived technical requirements from the Solution Definition Process described in this subsection. The relationships of the Solution Definition Process/Sub-processes are shown in Figure 4.3.2a.

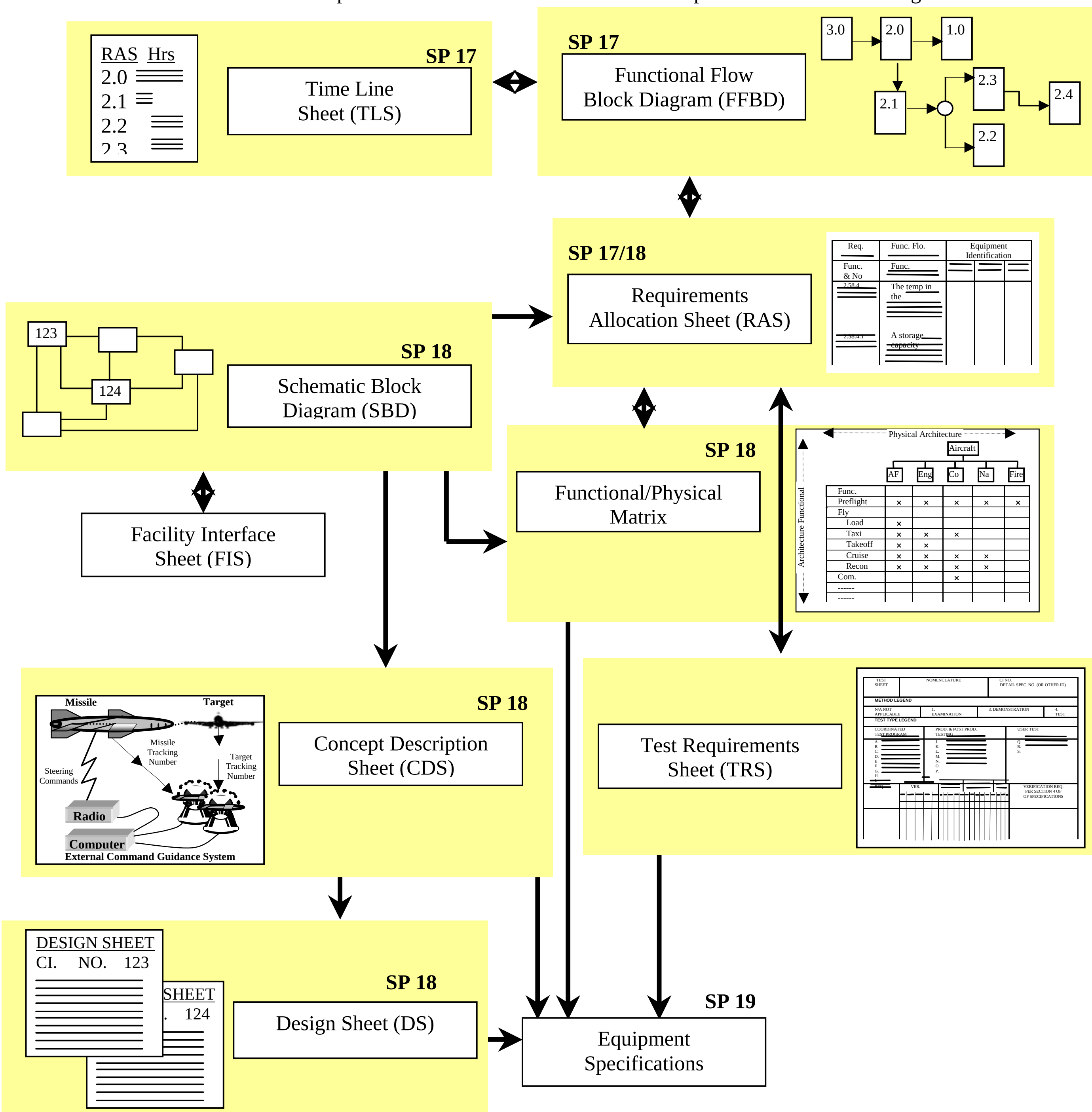


Figure 4.3.2a – Solution Definition Process/Sub-process relationships

The three sub-processes associated with the Solution Definition Process are shown in Figure 4.3.2b.

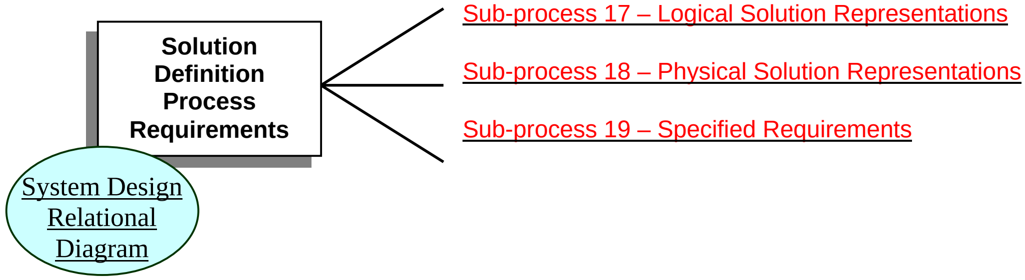


Figure 4.3.2b – Solution Definition Process/Sub-processes

NOTE – The purpose of the sub-processes related to the Solution Definition Process is to solve the technical problem. This involves identifying alternative end products for the system, selecting and defining an optimal set of end products, defining the feasible subsystems related to the end products, identifying requirements for enabling products, and identifying needed high-risk technology developments.

Sub-process 17– Logical Solution Representations

The developer **shall** define one or more validated sets of logical solution representations that conform with the technical requirements of the system.

Preceding Process

Requirements Design Process
    Sub-process 16: System Technical Requirements
Systems Analysis Process
    Sub-process 22: Effectiveness Analysis
    Sub-process 23: Trade-off Analysis
Requirements Validation Process
Sub-process 25: Requirements Statements Validation
    Sub-process 29: Logical Solution Representations Validation

Inputs

- System Technical Requirements (SP 16)
- Operational Capabilities (SP 16)
- Physical and functional requirements (SP 16)
- Mission Areas (SP 16)
- Cycle timelines (SP 16)
- Measures of Performance (MOP) (SP 16)
- Key Performance Parameter (KPP) (SP 16)
- Functional performance (SP 16)
- Human interface requirements (SP 16)
- Function concurrency / capacity (SP 16)
- Enabling products requirements (SP 16)
- Conflicting requirements (SP 16)
- System Requirements Document (SRD) (SP 16)
- Effectiveness Analysis Report (SP 22)
- Effectiveness Models (SP 22)
- Trade-off Analysis Technical Report (SP 23)
- Requirement statement validation revisions (SP 25)
- Logical solution representation validation revisions (SP 29)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents.

Tasks
The reason for developing logical solutions/functional system representations is to define Derived Technical Requirements (DTR). Identified logical representations shall be analyzed to determine the lower level requirements to accomplish the parent requirements. All specified usage modes shall be analyzed. Logical solution requirements shall be arranged so that lower level requirements (derived or otherwise) are recognized as part of higher level requirements (assure traceability from output products from *Initial Specification from Acquirer*, ***Sub-process 14***, *Other Requirements from Internal and External Sources*, ***Sub-process 15*** and *System Technical Requirements*, ***Sub-process 16***) (see Chapter 4.2.3 of this Guidebook for reference to the Requirements Traceability Matrix). For example the logical solution representation should be traceable to the functional description and functional flow block diagram.

The developer **should** plan and do appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Select and implement one or more appropriate approaches to providing an abstract definition of the solution to the system technical requirements**. For the approaches selected, complete the appropriate tasks from b) through d) below that aid in defining logical solution representations.

   The approach can be a combination of various approaches tailored to the type of system at a given system level. The application of the various analyses, or a combination thereof, is dependent on many variables, such as system type (e.g., hardware, or software), size, and the functional complexity.

   The traditional systems engineering approach for developing Logical Solution Representations has been the *Functional Analysis*. This approach is primarily supported by the development of Functional Flow Block Diagrams and the Functional Decomposition methods. Other types of analyses have been developed to support Logical Solution Representations; each method favors particular system types and development activities and has advantages and disadvantages. For example, the *Structured Analysis*, which includes context diagrams, control/data flows, data dictionaries, entity-relationships diagrams, and state transition diagrams, is typically applied in development of complex software intensive systems (i.e., Air Traffic Control System). Another type, the *Object Oriented Analysis* using Use Case /Unified Modeling Language (UML), is commonly applied in the development of information systems and other software applications. The resultant output of this task is typically a logical solution analysis approach. The analyses considered for the range of system/software are shown in Figure 4.3.2c. In task b), one must establish a method / approach to the System Technical Requirements (STR). That task defines these methods in more detail including the specific procedures that should be considered for developing a Logical Solution.

   A combination of these may be used for a system that contains both hardware and software. One approach might be to perform a functional analysis at the system level and use Object Oriented Analysis (OOA) for the software elements. If multiple approaches are used, traceability must be maintained across methodologies.

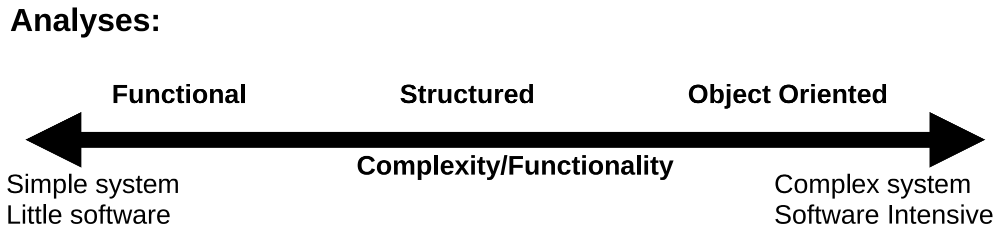


Figure 4.3.2c – Analyses considered for system/software

NOTE – Functional analysis, object-oriented analysis, structured analysis, and information engineering analysis are recognized approaches found in text books and other literature to develop logical solution representations in terms of, for example, functional flows, behavioral responses, state and mode transitions, timelines, control flows, data flows, information models, object services and attributes, context diagrams, threads, data structures, and functional failure modes and effects.

b) **Establish sets of logical solution representations** by: (1) doing trade-off analyses (see **Sub-process 23**); (2) identifying and defining interfaces, states and modes, timelines, and data and control flows; (3) analyzing behaviors; and (4) analyzing failure modes and defining failure effects.

Functional Analysis

- Functional Flow Block Diagram (FFBD): The translation of the system operational concept into a series of time-sequenced blocks that contain a description of the system function.

- Functional Decomposition: The break down of the system functions from higher level to lower level. This approach is not time sequenced.

- Timelines and Sequencing - When time is critical to the sequencing of events that a system must perform, a time-line analysis shall be conducted. A method for defining timing and sequencing is the Time Analysis Sheet (see DAU SE Fundamentals) and Time Line Analysis Chart (see INCOSE 1998, 4.3). Some of the automated systems engineering tools provide the capability to perform a simulation and give time line charts.

Structured Analysis

- Context Diagram: A diagram that shows the system and its interfaces with external components/elements.

- Control Data Flow Diagrams: Data & Control Flow diagrams are used to document all data transmission, control, and processing functional requirements (see INCOSE 1998, 4.3).

- Data Dictionaries: A data dictionary is an organized listing of all the data elements that are pertinent to a system. It should be used to describe data elements in both the Control Data Flow Diagrams and Context Diagrams. It should contain name, type, kind, and description.

- Activity Models : A diagram that identifies the system entities (other systems, devices, or people that the system must keep track of) connected by an arrow that is labeled with the cause/effect relationship (verbs) with other entities in the diagram.

- State Transition Diagrams: A diagram that shows the possible modes and states that the can exist in the system and the event or action under which the system can transition. Preliminary States and Modes are derived from the Concept of Operations (**Sub-process 14**) and the System Technical Requirements (STRs) (**Sub-process 16**) are further refined in increased detail. A top-level draft of this may be generated as a part of **Sub-process 16**, task a.

Object Oriented Analysis (OOA) (Booch 1994, p 155)

- Classical Approach: Definition of the system through categorization of things, roles, events, and interaction.

- Behavior Analysis: Definition of the systems through the grouping of objects that exhibit similar behavior.

- Domain Analysis: Definition of the systems based on objects, operations and relationships that are important to the domain (technical area).

- Use Case Analysis/Unified Modeling Language (UML): Definition of the system based on a particular form or example of usage/scenario. This also supports analyzing behaviors.

Logical Solution Trade-Off Analyses
An optimum logical solution representation should be developed by formulating alternative sets and down-selecting through the trade-off process. Trade Studies (see **Sub-process 23**) of alternative system logical solutions must be performed by taking into account cost, customer/user requirements (fleet project team input), open system considerations, and constraints such as the customer requesting the use of a specific Commercial Off-the-Shelf (COTS) product or interface with legacy systems.

After the appropriate approach is selected (*Functional Analysis*, *Structured Analysis*, or *Object-Oriented Analysis),* ensure the following analytical techniques are applied in the trade-off decision process where appropriate.

- Defining Interfaces (N2 Charts) - Logical solution requirements shall be sequenced with input, output, and logical solution interface (internal and external) requirements defined; and be traceable from beginning to end conditions and across their interfaces. A method for defining functional interfaces is the N2 chart (INCOSE 1998, 4.3). Description of interface is critical in taking an Open Systems Approach to system definition.

- Analyzing Behaviors - Analyze system logical solution behavior through simulation. Some of the automated systems engineering tools provide the capability to perform a run-time simulation and check various system logic and threads / paths through the system logical solution definition.

- Failure Modes, Effects and Criticality Analysis (FMEA/FMECA) - Analyze, define and prioritize logical solution (functional level) failure modes and effects through a Failure Modes and Effects Analysis / Failure Modes Effects and Criticality Analysis (FMEA/FMECA) (see references MIL-STD-1629 and DI-ILSS-81163A). This analysis shall be used to define fault detection, isolation, and recovery functions such as Built-in-Test and redundancy requirements.

c) **Assign (i.e., perform Requirements Allocation of) system technical requirements** (especially performance requirements and constraints from the system technical requirements) **to elements of the logical solution representations**, e.g., subfunctions, groups of subfunctions, objects, and data structures.

Establish performance requirements for each logical solution requirement (Functional Area) and interface. A method for gathering requirements allocation is the Requirement Allocation Sheet (RAS) (see, DAU SE Fundamentals and **DI-GDRQ-81222**). Time requirements that are prerequisite for a logical solution or set of logical solutions shall be determined and allocated. The resulting set of requirements shall be defined in measurable terms, applicable go/no-go criteria, and in sufficient detail for use as design criteria. Performance requirements shall be traceable throughout the logical solution architecture, through the analysis by which they were allocated, to the higher-level requirements they are intended to fulfill. Logical solution architecture refers to logical solution definition of the system and the allocation of performance requirements to these functions, not the hardware/software architecture.

NOTES
1 There can also be *system technical requirements* that are neither appropriate to assign to the sets of *logical solution representations* nor modifiable into *derived technical requirements*. An example is a characteristic or constraint applicable only to the system, not to the products of the system. These system technical requirements must be analyzed and assigned during *Physical Solution Representation*, **Sub-process 18**, tasks a), b), and c). 2 There will be additional derived technical requirements prepared to reflect system analysis results from *Physical Solution Representation*, **Sub-process 18** task c).

d) **Identify and define derived technical requirement statements resulting from tasks a) and b)**. Ensure that the derived technical requirements are stated acceptably in accordance with Requirements Statements Validation, **Sub-process 25**.

e) **Ensure that each set of logical solution representations is correct** in accordance with Logical Solution Representations Validation, **Sub-process 29**.

f) **Record the resulting sets of logical solution representations, the set of derived technical requirement statements, and any unassigned system technical requirements** (see notes under task c) above)**, along with source rationale and assumptions in the established information database** in accordance with Outcomes Management **Sub-process 12**.

Outputs

All outputs should be archived (SP 12)

- Functional Analysis Products (SP 18)
  - FFBD / Functional Decomposition
  - Timeline
- Structured Analysis Products (SP 18)
  - Context / QFD / Data Dictionaries / Entity-Relationship / Modes & States Diagrams
- Object Oriented Analysis Products (SP 18)
  - Classical / Behavior / Domain / Use Case Analyses
- N2 / FMEA / FMECA / RAS (SP 18)
- Effectiveness Analysis Request (SP 22)
- Trade options and constraints (SP 23)
- Derived Technical Requirements (SP 25)
- Logical Solution Representation (SP 18, 29)

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents.

Next Processes

Control Process
  Sub-process 12: Outcomes Management
Solution Definition Process
  Sub-process 18: Physical Solution Representations
Systems Analysis Process
  Sub-process 22: Effectiveness Analysis
  Sub-process 23: Trade-off Analysis
Requirements Validation Process
  Sub-process 25: Requirements Statements Validation
  Sub-process 29: Logical Solution Representations Validation

Agents

Systems Engineering, R&M, Human Systems Integration, Safety, Design, Logistics, Test, Software Development

Tools
Requirements Management & System Architecture Database (ex. CORE™, DOORS, SLATE™), Simulations, RAS

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

Systems Engineering Analysis (Blanchard)
Standard Practice for Performing FMECA (MIL-STD-1629),
DI-ILSS-81163A
Requirement Allocation Sheets (RAS) Data Item Description **DI-GDRO-81222**
Object Oriented Analysis & Design (Booch)
Modern Structured Analysis (Yourdon)

Metrics and Measures
Percent Completion of Logical Solution Products
Percent of Logical Solution Products that have been validated.

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this requirement, when combined with the system technical requirements, provide the basis for developing alternative physical solution representations.

NOTES

1 Conditions for logical groupings are determined by many factors and vary from one project to another. One common driver for logical groupings is to enable the use of existing products, and thus lessen development time and cost. Another common reason is to gain some advantage by introducing a particular new technology. In either of these cases, the grouping can result in interfaces that did not previously exist. New requirements have to be derived to accommodate these.

2 Accomplishment of the tasks associated with this sub-process is often iterative because outcomes raise questions that require certain tasks of the Requirements Definition Process to be reaccomplished. In turn, certain tasks associated with defining logical solution representations and derived technical requirements are reaccomplished. Such iteration is important in order to lessen the possibility of more costly iterations of System Design Processes during a later engineering life-cycle phase.

Derived technical requirements and requirements associated with logical solution representations **should** be incorporated into traceability procedures. This will enable ensuring that system technical requirements are properly supported by the derived technical requirements and logical solution representations.

Sub-process 18 – Physical Solution Representations

The developer **shall** define a preferred set of physical solution representations that agrees with the assigned logical solution representations, derived technical requirements, and system technical requirements.

Preceding Process

Requirements Definition Process
- Sub-process 16: System Technical Requirements

Solution Definition Process
- Sub-process 17: Logical Solution Representations

Systems Analysis Process
- Sub-process 22: Effectiveness Analysis
- Sub-process 23: Trade-off Analysis
- Sub-process 24: Risk Analysis

Requirements Validation Process
- Sub-process 25: Requirements Statements Validation

Inputs

- Design constraints (SP 16)
- Technology constraints (SP 16)
- Functional Analysis Products (SP 17)
  - FFBD / Functional Decomposition
  - Timeline
- Structured Analysis Products (SP 17)
  - Context / QFD / Data Dictionaries / Entity-Relationship / M&S Diagrams
- Object Oriented Analysis Products (SP 17)
  - Classical / Behavior / Domain / Use Case Analyses
- N2 / FMEA / FMECA / RAS (SP 17)
- Logical Solution Representation (SP 17)
- Effectiveness Analysis Report (SP 22)
- Effectiveness Models (SP 22)
- Trade-off Analysis Technical Report (SP 23)
- Risk Analysis Report (SP 24)
- Requirement statements validation revisions (SP 25)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents.

Tasks

The developer **should** plan and do appropriate tasks to complete this sub-process. These tasks for this sub-process are normally referred as System Architecture Synthesis (see INCOSE 1998, Section 4.4). The System Architecture Synthesis is part of the overall system design process, and it runs iteratively with Requirements Definition and Functional Analysis (Logical Solution Representations). Tasks to consider include the following:

a) **Analyze logical solution representations, derived technical requirements, and any unassigned system technical requirements** [see note under **Sub-process 17**, task c)] to determine which ones (1) provide requirements for enabling products; (2) can be done best manually or by facilities, materials, data, services, or techniques; and (3) can be done best by hardware, software, or firmware products (new or existing).

   The developer shall initiate the physical solution representation analysis by defining alternatives of the system hierarchy. This hierarchy is described in Section 6.2 of this document. These system hierarchy alternatives create the design space for all possible choices of elements. The system hierarchy is derived from the logical solution representation, and its purpose is to create the system elements, which constitutes the building blocks from which the system architecture is generated. The system elements include hardware, software, information, procedures, and people; and are defined top down beginning with the system, subsystem, and configuration items.

NOTES – The system hierarchy can be applied in the planning process to develop the Work Breakdown Structure (WBS) in accordance with the building block concept that consists of the breakdown of end products and enabling products.

b) **Assign representations from Sub-process 17, unassigned system technical requirements, and derived technical requirements to physical entities that will make up a physical solution**.

The developer shall assign (Requirements Allocation) logical solution representation in the form of functions and system technical requirements (i.e., performance, reliability, maintainability, interfaces, environmental requirements, human systems integration, survivability, safety, security, supportability, materials, cost, and other constraints) to the physical elements in the system hierarchy, thus creating a design space and range of values for those physical elements alternatives. These allocations and design descriptions for each physical element should not be constrained by the values of other elements. Assignments (Allocation) of design requirements shall be based on the mathematical formulation and representations relative to that discipline (i.e., Performance Models, Reliability & Maintainability Model and Schema, etc.). After requirements assignments are completed, the next step is the identification of the Systems Hierarchy Specification Tree for the various system elements alternatives.

NOTES – The assignment to physical entities and the generation of alternative solutions composed of these entities are tightly coupled and iterative.

c) **Generate alternative physical solutions by:**

Sizing, configuring, and integrating of the physical system elements alternatives in relation to the logical representation options and assigned requirements range. At this point, the developer shall begin to synthesize the system architecture alternatives. This approach together with the Schematic Block Diagram (SBD), Systems View (C4ISR Architecture Framework) and N2 diagrams enables the generation of architectural alternatives (see DAU SE Fundamentals, Chapter 6 and INCOSE 1998 Section 4.4.3 for further details). In developing these architectural alternatives, the developer shall consider the following:

1) **Identification and definition of physical interfaces** to include Information Exchange Requirments (IERs)

2) **Identification and analysis of critical parameters** (MOEs and TPMs)

3) **Identification and assessment of physical solution options**:
   a. Technology Requirements
   b. Off-the-shelf availability and non-developmental items (NDI)
   c. Competitive considerations
   d. Failure modes, effects, and criticality (Integrated Diagnostics / Testability)
   e. Performance assessment
   f. Life cycle considerations
   g. Capacity to evolve
   h. Make versus buy
   i. Standardization considerations (Open System Architecture)
   j. Integration concerns

4) **Performance of system analysis** (see **Sub-process 22**, **23**, and **24**), including performance design and parametric analyses to optimize operating target parameters. This effort helps establish sensitivities, connects hardware requirements to mission measurables, exposes thresholds and risks, and creates the range for robust design goals. The System Analysis will include considerations in the design for: performance, cost, reliability and maintainability, testability (reference integrated diagnostics, supportability, manufacturability, maintainability, safety,

security, and producibility). Supportability and Logistics Support Analysis (LSA) plays a key role in the development of physical solution representation. For many of the above "ilities", the Navy has specific functional divisions within the Systems Engineering department. **Appendix G** lists many of the references for these disciplines. This should include analyses of R&MSS, Human Systems Integration Engineering, Electromagnetics (EM), Survivability, Materials, Parts, Environmental, Supportability Design, LSA, Open System, COTS/NDI, and System & Performance Design.

d) **Identify and define derived technical requirement statements resulting from tasks a), b), and c) that are stated acceptably in accordance wit**h **Sub-process 25** (see INCOSE 1998, Section 4.4.4 for further details).

e) **Select the preferred physical solution representation for further characterization into a design solution** from the evaluation of each physical solution representation results (see **Sub-process 22**, **23**, and **24**). Document the physical solution concept using the Concept Description Sheet (see DAU SE Fundamentals) and the Design Sheet.

f) **Ensure that the selected physical solution representation is consistent** with the assigned logical solution representations, derived technical requirements, and any unassigned system technical requirements (see note under **Sub-process 17**, task c).

g) **Record the selected physical solution representation** and the outcomes of task d) above, along with selection rationale and assumptions, in the established information database.

Derived technical requirements and requirements associated with logical solution representations **should** be incorporated into traceability procedures. This will ensure that system technical requirements are properly supported by the derived technical requirements and logical solution representations.

Outputs *(List of sub-processes where output is used may include the originating sub-process.)*
All outputs should be archived (SP 12)

- Effectiveness Analysis Request (for alternative physical solutions) (SP 22)
- Trade options and constraints (SP 23)
- Risk Analysis Request (SP 24)
- Physical Solution Options (SP 18)
- Derived technical requirements (SP 25)
- Selected physical solution representation (SP 19, 30)
  (to include supporting documentation, e.g., Concept Description Sheet, Design Sheet, System Hierarchy Definition, Functional and Performance Allocation, System Specification Tree (HWCI / CSCI), FFBD & System Schematic, FMEA / FMECA (Based on FFBD), Integrated Diagnostic Analysis (Testability), System Architecture Views)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents.

Next Processes
Control Process
  Sub-process 12: Outcomes Management
Solution Definition Process
  Sub-process 19: Specified Requirements
Systems Analysis Process
  Sub-process 22: Effectiveness Analysis
  Sub-process 23: Trade-off Analysis
  Sub-process 24: Risk Analysis
Requirements Validation Process
  Sub-process 25: Requirements Statements Validation

System Verification Process
Sub-process 30: Design Solution Verification

Agents
Systems Engineering, R&M, Human Systems Integration, Safety, Security, Design, Logistics, Test, Producibility, Software Design

Tools
Requirements Management & System Architecture Database (ex. CORE™, DOORS, SLATE™)
SBD
N2 Diagrams
Requirement Allocation Sheets (RAS)
Concept Description Sheet and Design Sheet

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

Systems Engineering Analysis (Blanchard)
Standard Practice for Performing FMECA (MIL-STD-1629)

Metrics and Measures

- Percent Completion of Physical Solution Products
- Percent of Physical Solution Products that have been validated.

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process provide the preferred physical solution representation that will be fully characterized during **Sub-process 19**. Additionally the outcomes show that:
(1) The preferred physical solution representation satisfies the assigned requirements of the logical solution representations, derived technical requirements, and system technical requirements; and
(2) The preferred physical solution representation is upward- and downward-traceable with respect to the assigned requirements of logical solution representations, derived technical requirements, and any unassigned system technical requirements [see notes under **Sub-process 17**, task c)].
Outcomes can be displayed as a hierarchical structure of physical entities, schematics, physical models, analytical models, or explosion diagrams.

NOTES
1 As each physical solution representation is defined, it usually is necessary to reaccomplish tasks related to the definition of logical solution representations to ensure that the final set of derived requirements and requirements associated with logical solution representation is traceable to the preferred physical solution representation, and vice versa.
2 Physical solution representation will eventually be composed of one or more of the following: hardware, software, firmware, material, data (e.g., manuals, and handbooks), doctrine, organization, training, materiel, leadership, personnel and facilities (DOTMLPF).

Sub-process 19 – Specified Requirements

The developer **shall** specify requirements for the design solution.

Preceding Process
Assessment Process
Sub-process 10: Progress Against Requirements
Solution Definition Process
Sub-process 18: Physical Solution Representations
Requirements Validation Process
Sub-process 25: Requirements Statements Validation
System Verification Process
Sub-process 30: Design Solution Verification
Sub-process 31: End Product Verification
End Products Validation Process
Sub-process 33: End Products Validation

Inputs
- Deficiencies and discrepancies (SP 10)
- Selected physical solution representation (SP 18)
- Requirement statements validation revisions (SP 25)
- Design solution deficiency and discrepancy reports (SP 30)
- End Product deficiency and discrepancy reports (SP 31)
- Operational Test / Follow-On Test & Evaluation (OT/FOT&E) Report (SP 33)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents.

Tasks
The developer should plan to do appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Fully characterize the design solution**.

b) **Ensure that the design solution is consistent with its source requirements** (selected physical solution representation requirements, associated system technical requirements, and derived technical requirements) in accordance with **Sub-process 30**. Progress against requirements will be re-entered when discrepancies and deficiencies are identified in **Sub-process 10** or **Sub-process 33**. This task will evaluate for appropriate action in the system design process.

c) **Specify requirements** (including functional and performance requirements, physical characteristics, and test requirements) **for the system, system end products, and subsystems of each end product, as applicable to the engineering life-cycle phase,** in accordance with **Sub-process 25**.

d) **Record the design solution work products**, including the specified requirements, **in the established information database** with all trade-off analyses results, design rationale, assumptions, and key decisions to provide traceability of requirements up and down the system structure.

e) **Establish projects to develop enabling products and to procure those that are off-the-shelf or will be reused**, that will satisfy identified requirements for the associated processes (production, test, deployment/installation, training, support or maintenance, and retirement or disposal) related to the system's end products.

Outputs *(List of sub-processes where output is used may include the originating sub-process.)*
All outputs should be archived (SP 12)
- Specified Requirements (SP 2, 3, 11, 20, 21, 25, 30, 31, 32) (System, subsystem, and interface specifications that describe the specified requirements (see below)) in the form of an Interface Control Document or Detailed Design Specification

- SSS (System / Subsystem Specification) – **DI-IPSC-81431**
- IRS (External Physical Interfaces) - **DI-IPSC-81434**
- IRS (Internal Physical Interfaces) - **DI-IPSC-81434**
- HWCI (HW Configuration Item)
- SSDD (System Architecture Design) - **DI-IPSC-81432**
- IDD (HW Interface Design Description) - **DI-IPSC-81436**
- CI Product Descriptions
- SRS (Software Requirements Specification) - **DI-IPSC-81433**
- CSCI (CS Configuration Item)
- IRS (Software Interface Requirements) - **DI-IPSC-81434**
- SDD (Software Design Description) - **DI-IPSC-81435**
- DBDD (DB Design Description) - **DI-IPSC-81437**
- IDD (SW Design Description) - **DI-IPSC-81436**
- SPS (SW Product Spec) - **DI-IPSC-81441**
- SVD (User SW Version Description) - **DI-IPSC-81442**

- Specified Requirements Products (SP19)
  - Parts lists
  - Procedural manuals
  - Data and other applicable design descriptions
  - Verified design solution
  - Drawings/Schematics (**MIL-STD-100G**)
  - Supportability Product Specs/Descriptions
- Enabling products development projects (SP 32)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents.

Next Processes
Acquisition Process
    Sub-process 2: Product Acquisition
    Sub-process 3: Supplier Performance
Assessment Process
    Sub-process 11: Technical Reviews
Control Process
    Sub-process 12: Outcomes Management
Implementation Process
    Sub-process 20: Implementation
Transition to Use Process
    Sub-process 21: Transition to Use
Requirements Validation Process
    Sub-process 25: Requirements Statements Validation
System Verification Process
    Sub-process 30: Design Solution Verification
    Sub-process 31: End Product Verification
    Sub-process 32: Enabling Products Readiness

Agents
Systems Engineering, R&M, Human Systems Integration, Safety, Design, Logistics, Test, Software Development

Tools
Requirements Management & System Architecture Database (ex. CORE™, DOORS, SLATE™)
Requirement Allocation Sheets (RAS)
Specification Standards

References

Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

Systems Engineering Analysis (Blanchard)
Standard Practice for Defense Specifications (MIL-STD-100G)
Data Item Descriptions:
System / Subsystem Specification (SSS) **(DI-IPSC-81431)**
Interface Requirements Specification (IRS) **(DI-IPSC-81434)**
System Architecture Design (SSDD) **(DI-IPSC-81432)**
Software Requirements Specification (SRS) **(DI-IPSC-81433)**
Software Design Description (SDD) **(DI-IPSC-81435)**
Database Design Description (DBDD) **(DI-IPSC-81437)**
Interface Design Description (IDD) **(DI-IPSC-81436)**
Software Product Specification (SPS) **(DI-IPSC-81441)**
User Software Version Description (SVD) **(DI-IPSC-81442)**

Metrics and Measures

- Percent Completion of Specified Requirements Products
- Percent of Specified Requirements Products that have been validated.

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process provide a fully characterized design solution that: (1) can be implemented through further development of subsystems, off-the-shelf procurement or reuse, coding, or fabrication; and (2) provide the basis for the assembly and integration of subsystem products into end products required for verification.

> NOTE – A fully characterized design solution can be in terms of, as appropriate: (1) specifications for the system, end products, subsystems, and applicable interfaces; (2) interface control drawings or descriptions, detailed drawings, or sketches; and (3) parts lists, data dictionaries, or other planned physical configuration records.

4.4 Product Realization

The Product Realization Processes are used to: (1) convert the specified requirements and other design solution characterizations into either a verified end product or a set of end products in accordance with the agreement and other stakeholder requirements; (2) deliver these to designated operating, customer, or storage sites; (3) install these at designated operating sites or into designated platforms; and (4) provide in-service support, as called for in an agreement.

The two processes related to Product Realization are shown in Figure 4.4.

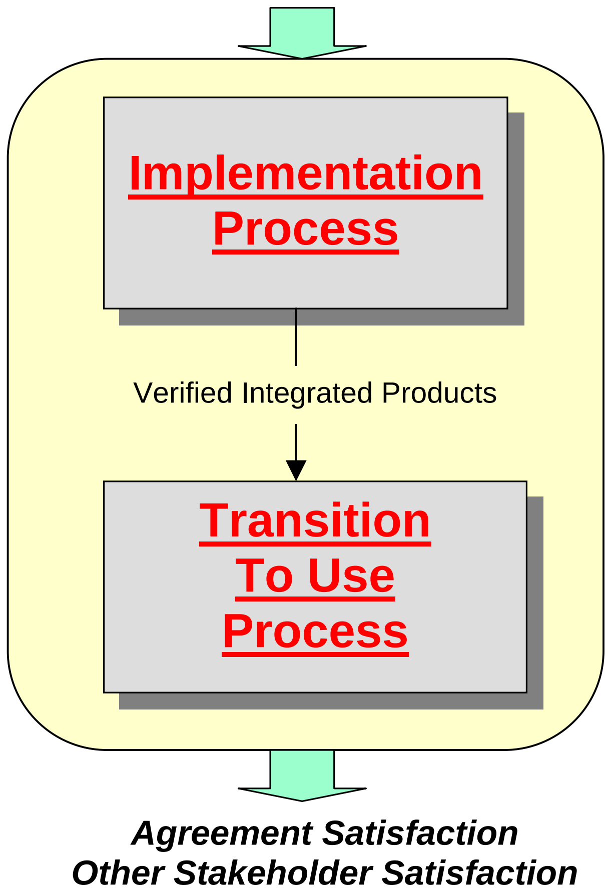


Figure 4.4 – Product Realization Process

4.4.1 Implementation Process

One sub-process is associated with the Implementation Process. It requires transforming the characterized design (preliminary or final) into an integrated end product that conforms to its specified requirements.

Sub-process 20– Implementation

The developer **shall** implement (build/assemble/code/test) the design (preliminary or final) in accordance with the specified requirements to obtain a verified end product.

Preceding Process
Supply Process

Sub-process 1: Product Supply
Planning Process
Sub-process 7: Technical Plans
Solution Definition Process
Sub-process 19: Specified Requirements
End Products Validation Process
Sub-process 33: End Products Validation

Inputs

- End Products (SP 1)
- Enabling Products (SP 1)
- Manufacturing Plans (SP 7)
- Quality Assurance (QA) Program Plan (SP 7)
- Specified Requirements (SP 19)
- Operational Test / Follow-On Test & Evaluation (OT/FOT&E) Report (SP 33)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents.

Tasks

The developer **should** plan and do appropriate tasks to complete this sub-process. Tasks to consider include the following.

a) **Receive from suppliers, reuse from off-the-shelf supply, or receive from the acquirer** (e.g., customer-furnished items) **the subsystem products that make up the system's end products, or, as appropriate, code or build the end products** (software/hardware) according to the specified requirements and detailed drawings or other design documentation. Tools for this task includes the following: Parts List, Parts Management Plan, Configuration Item Lists, Make/Buy Analysis, integrated architecture products and Government Furnished Equipment (GFE) Management. This includes ensuring when we are responsible for building the end product; and ensuring each component or piece part meets its specification.

> NOTE – **Sub-process 3**, Supplier Performance, is invoked whenever subsystem products are acquired from suppliers or lower-tier developers outside the enterprise, as well as when the supplier is an organizational entity within the developer's own enterprise.

b) **Validate the subsystem products received or reused against their acquirer requirements** (input requirements to the subsystem product development) using the End Products Validation Process, **Sub-process 33**, unless (1) the supplier validated the products prior to delivery as required in the agreement, or (2) the reused products have already been validated. Proof of validation is needed for both conditions. Approval of Suppliers' products is obtained through compliance to product specifications. This could be ascertained at suppliers' facilities, receiving incoming or via receipt inspection, first article validation, and/or test/demonstration. See ISO 9001 Section 4.6.2 for vendor management.

c) **Assemble the validated subsystem products, or physically integrate such products into the respective test article or end product to be verified**. This should be accomplished through already approved Manufacturing and Quality Assurance Program Plans.

d) **Verify each test article or end product against its specified requirements** (output requirements of the system end product development) in accordance with **Sub-processes 30** and **31**. Developmental Test & Evaluation (DT&E) (Sub-process 31) accomplishes such a task for end products, and the design solution verification (Sub-process 30) does this for test articles (brassboards).

e) **Ensure**, in accordance with **Sub-process 32**, **that the enabling products for each associated process will be ready and available to perform their intended support functions required by the system's end products**. An area often missed is confirming dedication of fleet assets. This should include CINC notification for fleet testing as well as GFE and other assets that will be required.

> NOTE – The relevant end products for enabling products are verified and validated as necessary during the development of the building block related to the enabling product (see Section 6). All essential systems engineering technical reviews (ITR, ASR, SRR, TRA, SFR, PDR, CDR, TRR, FRR, SVR/PRR, PCR, ISR, etc.) should be completed to ensure that enabling processes and resources are ready and available.

A major Production Readiness Review (PRR) is conducted at the end of SDD to ensure that the program is ready to proceed into Low Rate Initial Production (LRIP). This review will validate the production facility, equipment, manufacturing processes, and personnel; and help ensure that the program will enter low rate production at a low risk. A subsequent PRR is usually conducted in LRIP to ensure the program is ready to transition from low rate to full rate production in Production & Deployment and Operations & Support phases.

f) **Validate the verified end products against their acquirer requirements** (input requirements to system end product development) prior to delivery, if required by the agreement, in accordance with **Sub-process 33**. Operational Test & Evaluation (OT&E) accomplishes such a task and this information is incorporated into the End Product or Enabling Product Report.

Outputs *(List of sub-processes where output is used may include the originating sub-process.)*
All outputs should be archived (SP 12)

- Assembled End Product(s) or Enabling Product(s) (SP 20)
- Manufacturing Process & Personnel System (SP 21)
- Verified and Validated Integrated End Product or Enabling Product Report (SP 21)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents.

Next Processes
Control Process
    Sub-process 12: Outcomes Management
Transition To Use Process
    Sub-process 21: Transition to Use

Agents
Prime Contractor, Suppliers, Program Management, Systems Engineering, Manufacturing, Quality Assurance (QA), Logistics, Testing, Financial Management, Procurement, Parts Management, End User, Defense Contractor Management Agency (DCMA)

Tools
Design tools; Integrated Enterprise Data Repository; Manufacturing Tooling; Technical Performance Measurement (TPM) Tracking Tools/Schedules (Earned Value Management – Schedule Performance Index (SPI)/Cost Performance Index (CPI), Availability Metrics, Reliability Metrics, and Effectiveness Metrics); Test Equipment, Test Requirements, Test Analysis; First Article Testing, Manufacturing Plan, Work Instructions, Statistical Process Control (SPC); Inspections, In-Process Inspection Plan, Production Process Flows, Integration Control Document, Configuration Systems (Work Breakdown Structure); and Production Readiness Review (PRR), Physical Configuration Review (PCR). Requirements Management & System Architecture Database (ex. CORE™, DOORS, SLATE™), Parts List, Parts Management Plan, Configuration Item Lists, Make/Buy Analysis, Government Furnished Equipment (GFE) Management, and integrated architecture products.

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**

FAR Parts 46 and 52.246
DFAR Part 46
ISO 9001
Defense Manufacturing Guide
MIL-STD-1528A
MIL-STD-1521B
DOD-STD-2168
DOD-STD-2167A
Systems Engineering Technical Reviews (SETRs)
Manufacturing Management Program

Metrics and Measures

- Adherence to Schedule and Progress Versus Plan
- Requirement Execution Time and Cost
- System Definition Detail
- Technical Performance Measurement Resolution (Availability, Reliability, Capability, and Effectiveness)
- Process Control Matrices

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process provide a fully integrated end product that: (1) satisfies its specified requirements; and (2) if required to be validated prior to delivery, conforms to its related acquirer requirements.

End product physical integration **should** ensure that: (1) internal and external interfaces for the composite end product (including systems; voice/data/information; and Doctrine, Organization, Training, Material, Leadership and People, and Facilities (DOTMLPF)) function according to specified requirements; (2) defined states, modes, dynamic allocations or other operational switching functions perform as required; and (3) and designed overload conditions, reduced operational levels, or designed-in degraded mode of operations are included.

4.4.2 Transition to Use Process

The Transition to Use Process results in products delivered to the appropriate destinations in the required condition for use by the acquirer and for the appropriate training of installers, operators, or maintainers of the products.

Sub-process 21 – Transition to Use

The developer **shall** transition verified products to the acquirer of the products in accordance with the agreement

Preceding Process

Acquisition Process
    Sub-process 2: Product Acquisition
Planning Process
    Sub-process 6: Schedule and Organization
Solution Definition Process
    Sub-process 19: Specified Requirements
Implementation Process

Sub-process 20: Implementation
System Verification Process
Sub-process 32: Enabling Products Readiness

Inputs

- Verified and Validated Integrated End Product or Enabling Product Report (SP 20)
- Manufacturing Process & Personnel System (SP 20)
- Integrated Master Schedule (IMS) (SP 6)
- Specified Requirements (for packaging and handling) (SP 19)
- Enabling Products Readiness determination (SP 32)
- ILS Certification (SP 2)
- Signed DD Form 250 (SP 2)

Entry Criteria

Inputs have been approved by the appropriate agents.

Tasks

The developer **should** plan and do appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Acquire and put in place appropriate enabling products to carry out relevant transition to use requirements**. Enabling products specifically looked for are:
   - Delivery addresses
   - Fleet release message
   - Installation procedures
   - Training
   - Operation and maintenance manuals (PHS&T)
   - In-service support equipment

b) **Prepare**, as required by the agreement, **end products for shipping and storage**.

c) **Store end products awaiting shipping and**, in accordance with the agreement, **ship or transport to the acquirer at the intended usage sites**.

d) **Prepare**, as required by the agreement, **sites where end products will be stored, installed, used or maintained, or serviced**.

e) **Install end products**, as required by the agreement, **at the appropriate sites**.

f) **Perform commissioning**, as required by the agreement, **to bring delivered or installed end products to operational readiness with appropriate acceptance and certification tests completed** in accordance with **Sub-process 33**.

g) **Provide**, if required by the agreement, **a parallel operation (ghosting) of the new and the legacy end products so that service is continuous during the transition period**.

h) **Provide**, in accordance with the agreement, **training for users, maintenance, and other personnel**.

i) **Provide**, in accordance with the agreement, **in-service support**.

j) **Deliver all planned support elements**.

Outputs *("EXT" indicates it is external, unspecified, and not for a sub-process.)*
All outputs should be archived (SP 12)

- Operational system products (EXT)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents.

Next Processes
Control Process
Sub-process 12: Outcomes Management

Agents
Logistics
Fleet Support Team (FST)
In-service Support
PM

Tools
Not Applicable

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

Metrics and Measures
Percent damaged products
On-time delivery

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process fulfill the delivery requirements of the agreement.

> NOTE – Transition to Use tasks will be dependant on whether the end product is being delivered for intended marketplace use or sale, or if the end product is delivered to another developer for integration into a set of other end products to make up an end product higher in the system structure.

4.5 Technical Evaluation

The Technical Evaluation Processes are intended to be invoked by one of the other processes for engineering a system. Four processes are involved: Systems Analysis, Requirements Validation, System Verification, and End Products Validation. The relationship between these processes is shown in Figure 4.5.

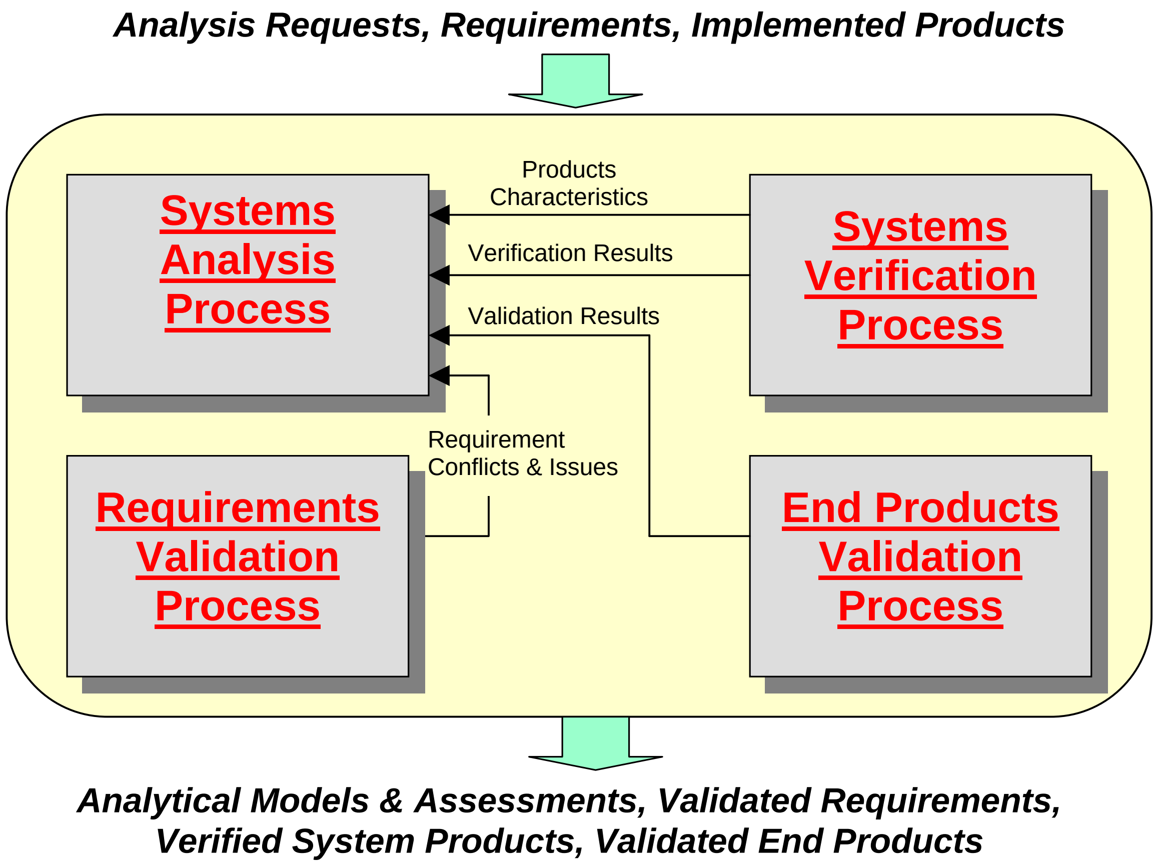


Figure 4.5 – Technical Evaluation Process

4.5.1 System Analysis Process

The Systems Analysis Process is used to: (1) provide a rigorous basis for technical decision making, resolution of requirement conflicts, and assessment of alternative physical solutions; (2) determine progress in satisfying system technical and derived technical requirements; (3) support risk management; and (4) ensure that decisions are made only after evaluating the cost, schedule, performance, and risk effects on the engineering or reengineering of the system.

The three sub-processes associated with the Systems Analysis Process, when invoked by other processes in this Guide, are shown in Figure 4.5.1a.

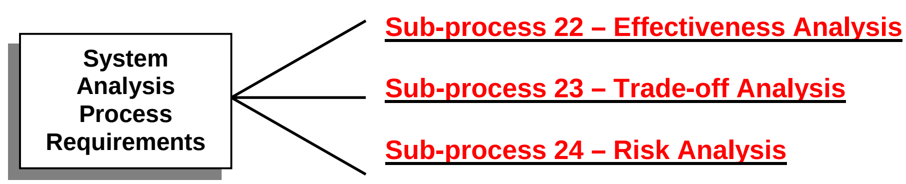


Figure 4.5.1a – System Analysis Process/Sub-processes

Completion of Systems Analysis sub-processes should ensure, as appropriate, that:

a) the effectiveness of each design solution is appropriately evaluated;

b) the effect on any interfacing products or platforms is evaluated for each alternative solution in time to support selection among these alternatives (this includes interoperability and integration effects of electronic interference and communication, as well as functional, human, and physical interfaces;

c) cost (e.g., unit production cost, developmental cost, and/or life cycle cost) is appropriately treated as an assigned requirement or as an independent variable when conducting trade-offs with technical requirements;

d) cost or price, schedule, performance, and risk effects of each functional, performance, and design alternative are defined, calculated, and reported;

e) estimated total ownership costs including hidden cost effects (for example, from manufacturing processes variability; excessive precision of manufacturing or test processes; special materials, finishes, and painting of products; and product complexity), the cost of operation, and all associated processes are known;

f) primary functional characteristics of solutions (for example, producibility, testability, deployability, operability, supportability, trainability, and disposability) are directly traceable to the functional and performance requirements they were designed to fulfill;

g) applicable product dependability factors such as availability, maintainability, reliability, safety, and security are not degraded;

h) projected environmental impacts are known;

i) design assumptions are valid and reasonable;

j) technology limits are recognized and understood; and

k) requirements can be validated and specifications verified in a cost-effective manner.

The developer should identify, acquire/develop, and implement models, including prototypes and simulations as applicable, to accomplish effectiveness analyses, do trade-off analyses, and complete risk analyses invoked by processes in this Guide.

The effectiveness analysis requirement is an integral part of a trade-off analysis (**Sub-process 23**). It can also be done as needed to analyze the effectiveness of the preferred solution selected during the activities of **Sub-process 18**, Physical Solution Representations. Also, effectiveness analyses should be used to support risk impact analyses and requirements definition in general.

Figure 4.5.1b illustrates the interrelationship of Effectiveness Analysis with trade-off Analysis (**Sub-process 23**) and Risk Analysis (**Sub-process 24**). One can do a risk analysis without also doing an effectiveness analysis or trade-off analysis (e.g., for doing risk management - **Sub-process 12**). However, an effectiveness analysis can also be done to support a risk impact assessment. One can do an effectiveness analysis without doing a risk analysis (e.g., for the physical solution definition - **Sub-process 18**). However, one does not do a trade-off analysis without also doing both a risk analysis and an effectiveness analysis (as illustrated by the line O-A in Figure 4.5.1b). Thus point A can be anywhere in the quadrant space except along the trade-off analysis axis. The degree of risk analysis and effectiveness analysis can vary depending on the case invoking the trade-off analysis.

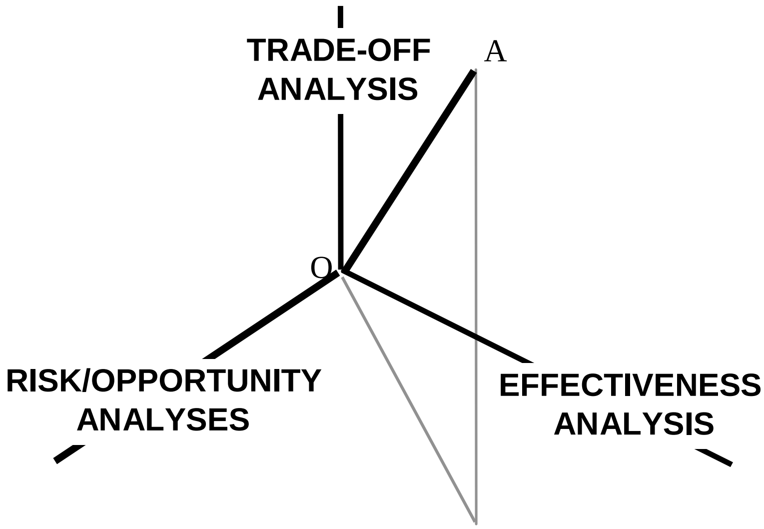


Figure 4.5.1b – Interaction of Systems Analysis Sub-Processes

Trade-off analyses provide a recommended course of action with impact to decision makers for each set of alternatives examined. The impact assessment is given in terms of cost, schedule, performance and risk/opportunity.

Opportunity analysis should be added to risk analysis. Opportunity analysis is important to include in a trade-off analysis because an opportunity offered by an alternative may be a driving force in making a recommendation. Opportunities exist in terms of the capacity to evolve. That is looking at the capacity to add improvements at a later date in order to improve competitiveness or to overcome an evolving threat to do technology refreshment that will make the product more efficient or cost effective, or to take advantage of a technology insertion that will improve performance. Opportunities also exist to be able to evolve one configuration into another without a new development effort. (One of the basics of evolutionary development.)

Effectiveness can be looked at as the measure of extent to which a system, or portion of a system, may be expected to achieve a set of specific objectives based on the alternative attribute or solution being analyzed. These objectives may be based on a mission profile, concept of operation, or overall functionality requirements of the system, or portion of the system, being analyzed. The analysis provides a quantitative determination of how well the resulting end product would meet four metrics – capability, dependability, suitability, and cost effectiveness. (See metrics at the end of **Sub-process 22**.)

The economic consequences of an alternative selection are an important consideration in decision-making. Therefore, in doing a trade-off analysis during development, sufficient cost trade-off data should be available to the decision maker so that alternatives can be compared in terms of capability, dependability, suitability criteria, as well as risk and opportunity.

Figure 4.5.1c provides the input - output relationships of Sub-processes 22, 23 and 24 as defined in this guide. Additionally, in dashed lines are the recommended relationship of Sub-processes 22 and 24 for situations when risk analysis is done without Sub-process 23 implementation.

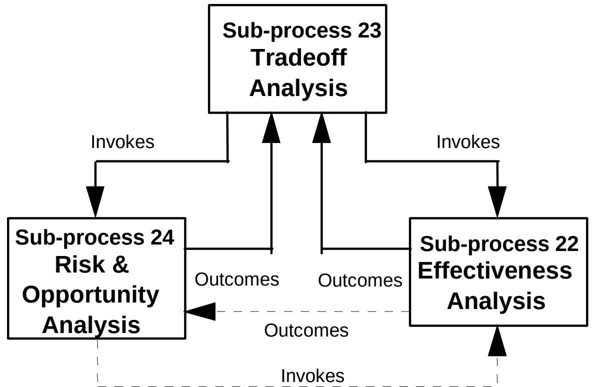
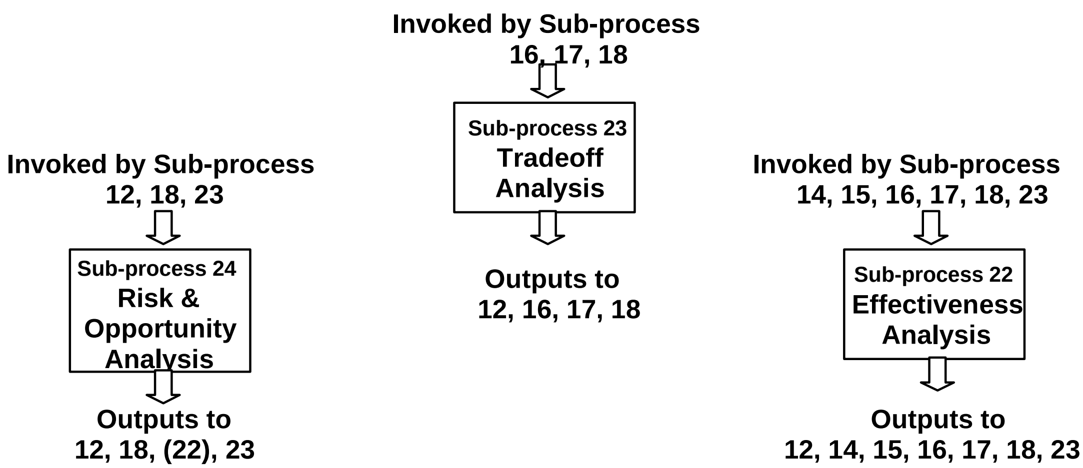


Figure 4.5.1c – Interrelationship of Systems Analysis Sub-processes

Figure 4.5.1d provides the sub-processes that invoke each Systems Analysis Process and it provides the sub-processes that may receive the outputs of each Systems Analysis Sub-process as defined in this guide. An added trigger and output destination for Sub-processes 22 and 24 are shown in parenthesis.



Note: Although tradeoff analysis is not explicitly call out while fully characterizing the design solution in **Sub-process 19**, such may need to be done.

Figure 4.5.1d – Sub-processes Invoking or Receiving Outputs from Systems Analysis Sub-processes

Sub-process 22 – Effectiveness Analysis

The developer **shall** perform effectiveness analyses to provide a quantitative basis for decision-making.

Effectiveness analyses are done to: (1) measure the extent each alternative physical solution considered during design may be expected to achieve system requirements; (2) assist in choosing the preferred physical solution for the end product being developed; and (3) aid in determining recommended courses of action and associated impacts for trade-off analyses. Effectiveness analyses are also used during: (1) System Technical Requirements definition to support performance analyses to determine a “knee in the curve” or some other identifiable characteristic that provides an optimal set of requirements; (2) Progress Against Requirements Assessments to

determine how well the design solution is maturing toward meeting agreement requirements; and (3) Technical Reviews for providing the review decision makers with the maturity of the design solution.

Preceding Process

Planning Process

Sub-process 5: Technical Effort Definition

Sub-process 7: Technical Plans

Requirements Definition Process

Sub-process 14: Acquirer Requirements

Sub-process 15: Other Stakeholder Requirements

Sub-process 16: System Technical Requirements

Solution Definition Process

Sub-process 17: Logical Solution Representations

Sub-process 18:Physical Solution Representations

Systems Analysis Process

Sub-process 22: Effectiveness Analysis

Sub-process 23: Trade-off Analysis

Inputs

- Technical Performance Measures (TPM) (SP 5)
- CAIV decision criteria (SP 5)
- System Engineering Plan (SEP) or Software Development Plan (SDP) (SP 7)
- Effectiveness Analysis Request (SP 14**,** 15, 16, 17, 18, 23)

An Effectiveness Analysis request can come from: (1) **Sub-processes 14** or **15** to request effectiveness analyses to aid in developing the understanding of customer requirements (i.e., mission analyses, measures of effectiveness; and operational concept analyses); (2) **Sub-process 16** to aid in developing the best set of technical performance requirements; (3) **Sub-process 17** to aid in forming logical solution representations and derived technical requirements; (4) **Sub-process 18** to aid in defining alternative physical solution representations or alternative attributes for a single physical solution representation or in selecting the preferred solution; and (5) **Sub-process 23** to aid in doing a trade-off analysis.

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents.

Request for effectiveness analysis is clear, concise, and valid; the input descriptive data is complete and consistent for the effectiveness analysis to be done; appropriate resources for doing the analysis are available; appropriate models and/or simulations are defined and available; and completion time constraints are defined and acceptable. In addition, the roles, responsibilities and authorities needed to do effectiveness analyses should be identified and defined, as well as assignment of the roles, responsibilities, and authorities to the appropriate team or individual.

Tasks

The developer **should** plan and do appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Plan effectiveness analyses to include purpose, objectives, execution and data collection, schedule of tasks, resource need and availability, and expected outcomes**.

The plans for doing effectiveness analyses should be done in conjunction with planning for systems analysis and include definition of any special techniques, procedures, tools needed, and simulations and modeling.

Effectiveness models should be created for specific characteristics of system functionality. These characteristics include, but are not limited to: operations (such as measures of effectiveness), supportability, reliability, maintainability, production, training, disposal, test/validation/verification,

deployment/installation, environmental, and total ownership cost (including design to cost or cost as an independent variable). Effectiveness models should allow parameters to be varied so that relative, individual effect on total system performance and life cycle cost can be determined. All effectiveness models must be validated to ensure valid analysis and simulation results.

b) **Analyze each alternative for system and cost effectiveness** based on factors such as accuracy, availability, capacity, maintainability, reliability, responsiveness, operability, safety, security, spares, requirements, survivability, transportability, and vulnerability. Navy Systems Commands have areas specifically assigned to engineering specialty such as ILS, producibility, and deployability. Often there are full plans specifically covering these areas when they are vital to the program development (see **Sub-process 7** and **Appendix D**). These plans provide further context for planning effectiveness analyses.

Cost may be treated like a performance objective (design to cost) or as an independent variable (CAIV). System and cost effectiveness analyses should include the following, as applicable:

1) Production engineering analysis and assessment to determine what it will take to manufacture or produce, including assembly and integration, the resulting end product. This includes: producibility-related design factors; alternative manufacturing and production approaches; impacts of long-lead-time items; and material, capacity, tools, equipment, and people limitations.

2) Test and evaluation analysis and assessment to determine what it will take to do necessary tests and evaluations on the resulting end products. This includes: analyzing the various kinds of validations, verifications, demonstrations, qualification, acceptance and other testing that may be needed; testability-related design factors; and test and evaluation requirements such as testing sites, facilities, site/facility capacities and limitations, people, and life-cycle testing consistency.

3) Deployment and installation analysis and assessment to determine the requirements and constraints associated with deploying and/or installing the resulting end product. This includes: factors for site/host selection, activation/installation, on-site assembly, and site-unique hazards; compatibility with existing infrastructures; environmental impact considerations; early deployment of training items and personnel; initial provisioning and spares; packaging, handling, storage, and transportation requirements and constraints; and site transition requirements.

4) Operation analysis and assessment to determine what it will take to satisfy operational requirements for the resulting end product. This includes: operation and support facility and equipment requirements; interoperability of interacting systems required to execute operational functions in the intended use environments; required joint and combined operations including other services, contractors and international partners; and planned and potential future operation uses.

5) Supportability analysis and assessment to determine what it will take to support end products over the life cycle. This includes: supportability-related design factors; all planned levels of maintenance; and support resources required such as people, parts, facilities, and materials.

6) Training analysis and assessment to determine what it will take to train users of the resulting end product. This includes: development of qualified personnel with appropriate skills, proficiencies and capabilities; initial and follow-on training requirements; and training resources required such as people, facilities, training materials, and how often re-training will be required (perishability of previous training).

Determine the sensitivity to constraints and uncertainties in input data and assumptions. When another system has comparable characteristics, it can be used as a baseline to support the determination, completeness, and achievability of effectiveness analysis requirements.

c) **Analyze each alternative for total ownership cost to the enterprise and to the acquirer**. The following costs are typically included in a total ownership cost analysis: development, production, test, deployment/installation, training, operations, support/maintenance, and retirement/disposal.

Of interest is determining the economic consequences of each alternative in terms of costs to the enterprise and to the acquirer for each alternative physical solution representation, alternative trade-off analysis option, or proposed change. As a result of this analysis, design-to-cost targets (if applicable), current estimate of system total life-cycle cost, and known uncertainties in these costs should be established.

d) **Analyze the environmental impact of each alternative**, including applicable environmental statutes and hazardous material lists, from an enterprise-based life cycle perspective (see **Appendix B**).

The system and its end products must operate within prescribed environmental definitions. The system/end products and the environment will interact in certain ways, and the goal is to minimize the adverse impact of the system/end products on its environment and the environment on the system/end products. Environmental impacts should include the natural environment (air, land, and water), organizational environment (enterprise and geo-political), and social environment (people, animal, plant, cultures, and religions).

It is important to understand the interfaces between the system/end products and the environment in terms of all materials and energies exchanged across the interface. Each interface is studied for ways of reducing environmental impact.

Likewise, environmental laws and regulations must be studied for compliance. The developer must adhere to all applicable statutes and agreements to designated hazardous material lists. Use of materials that present a known hazard will be avoided to the extent possible. Legal implications to the government should be identified and defined.

An environmental impact analysis should include, as applicable:

1) Environmental analysis and assessment to determine the impact on and by each end product and enabling product alternative on factors such as noise pollution, quantities and types of hazardous materials used, hazardous waste disposal, and other defined environmental requirements applicable. This includes, from an enterprise-based life cycle perspective: the applicable federal, state, municipal, and international environmental statutes and applicable hazardous material lists affecting the project; endurance of compliance by each physical solution end product; and the effect on and by each end product and enabling product on the infrastructure, land and ocean, atmosphere, water sources, and animal, plant and human life, as applicable.

2) Disposal analysis and assessment to determine what it takes to dispose of end products and by-products. This includes: disposability-related design factors; identifying environmental factors for process wastes and outputs as well as used end products and their subsystems; consideration of various disposal methods such as storage, dismantling, demilitarization, reusing, recycling, and destruction; and people, costs, sites, responsible agencies, handling and shipping, supporting items, and applicable federal, state, local, and host nation regulations.

e) **Analyze each alternative for each required operational profile to provide an analytical confirmation that the alternative satisfies appropriate requirements**. This task uses the outputs of tasks b) through d) above as inputs to analyze each alternative.

For analysis of alternative physical solution representations or of the preferred physical solution, satisfaction of the set of derived technical requirements should be confirmed.

For analysis of alternative attributes (for requirement conflict resolution) or for evaluating logical solution representations, the impact on the ability to satisfy the defined system technical requirements within acceptable costs and risks should be considered.

f) **Record effective analysis outcomes in the established enterprise data repository**, including assumptions, details of the analysis, findings, lessons learned, models used, rationale for decisions made, and other pertinent information that affects the interpretation of the effectiveness analysis results.

The results of the effectiveness analysis should be provided to the requesting source and recorded in the enterprise data repository (**Sub-process 12**). It is important for follow-on analyses that models, data files, and their documentation be maintained, updated and modified as required. Each version of a model or data file that impacts requirements, design, or decisions should be entered into the enterprise data repository.

Outputs *(List of sub-processes where output is used may include the originating sub-process.)*
All outputs should be archived (SP 12)

- Effectiveness Analysis Plan (SP 22)
- Effectiveness Models (SP 14, 15, 16, 17, 18, 23)
- Production Engineering Assessment (SP 22)
- Test & Evaluation Assessment (SP 22)
- Deployment & Installation Assessment (SP 22)
- Operations Assessment (SP 22)
- Support Assessment (SP 22)
- Training Assessment (SP 22)
- Total Ownership Cost Assessment (SP 22)
- Environmental Assessment (SP 22)
- Disposal Assessment (SP 22)
- Effectiveness Analysis Reports (SP 14, 15, 16, 17, 18, 23, 24)

Effectiveness Analysis Reports are provided to the requestor of the effectiveness analysis and captured in the enterprise data repository. Each report will document the results of the effectiveness analysis in accordance with the agreement and effectiveness analysis plan to include: outcomes from each analysis and assessment made and who approved the results; input data used and who approved the data; models used; and related data files, assumptions, and lessons learned. Some examples of types of reports/analyses may include Mission Area Analysis (MAA), Measures of Effectiveness (MOE), Mission analysis, Analysis of Alternatives, System concept analysis, etc.

For effectiveness analyses that support **Sub-processes 14** or **15** – Acquirer requirement and other stakeholder requirements are analyzed to determine warfighter deficiencies and to analyze technology opportunities for increased systems effectiveness and/or cost reductions.

For effectiveness analyses that support **Sub-process 16** – System Technical Requirements, outcome data includes:

- the effectiveness of various mixes of requirements without regard to the means of implementation (except for legacy systems for which changes of performance are being considered), and
- effectiveness to help come up with a “knee in the curve” or some other identifiable characteristic that provides an optimal set of requirements.

For effectiveness analyses that support **Sub-process 17** – Logical Solution Representation, the outcome data are very similar to those for **Sub-process 16** in that effectiveness of various logical representations are considered without regard to the means of implementation (except for legacy systems).

For effectiveness evaluations to support trade-off analyses of alternative physical solution representations or an evaluation of the preferred physical solution (**Sub-process 18**), the outcome data provides a quantitative

assessment of the value of a point design solution. The objective of these evaluations is to measure how well the point design meets its set of derived requirements. For systems effectiveness assessments that support **Sub-process 18**, outcome data includes, as applicable:

- overall system or system product effectiveness for each operational profile with respect to satisfying acquirer requirements within acceptable risks
- impact on enabling product requirements with respect to each associated process (development and integration, production/manufacturing, test, deployment, training, operations, support, and disposal)
- system cost effectiveness with respect to attributes such as: capability (accuracy), dependability (availability, reliability, operability, survivability, and vulnerability), and suitability (capacity, maintainability, responsiveness, safety, security, spare requirements, and transportability)
- total ownership costs to the enterprise, acquirer, and/or user, including the known uncertainties (risks) in these costs
- compliance impacts of applicable federal, state, municipal, and international environmental statutes and applicable hazardous material lists, as well as legal liabilities
- environmental impacts on the land and ocean, atmosphere, water sources, and animal, plant and human life.

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents.

For analysis of alternative physical solution representations or of the preferred physical solution, satisfaction of the set of derived technical requirements should be confirmed within acceptable levels of risk and within acceptable costs.

For analysis of alternate attributes for requirement definition conflicts or logical solution representations, satisfaction of the defined set of technical requirements for the system should be confirmed within acceptable levels of risk and within acceptable costs.

Next Processes

Control Process
- Sub-process 12: Outcomes Management

Requirements Definition Process
- Sub-process 14: Acquirer Requirements
- Sub-process 15: Other Stakeholder Requirements
- Sub-process 16: System Technical Requirements

Solution Definition Process
- Sub-process 17: Logical Solution Representations
- Sub-process 18: Physical Solution Representations

Systems Analysis Process
- Sub-process 23: Trade-off Analysis
- Sub-process 24: Risk Analysis

Agents

Legal
Systems Engineering
(The Systems Engineering Manager is the primary agent for approval of inputs to effectiveness analysis and for approving effectiveness analysis outputs.)

Tools

Effectiveness models and integrated architecture products should be used when they can contribute to the decision process. Effective models allow parameters to be varied so that their relative, individual effect on total system performance or end product performance and life cycle cost can be determined. Specific models will depend on the system or end product being analyzed, its size, its location in the total system architecture, and the phase of development within the DoD Acquisition Process. Early effectiveness modeling during feasible concept trade-off studies may take a functional view, while later modeling during physical design trade-off analyses may shift to a product view.

Integrated architectures provide a logical, structured approach for defining how forces operate by defining the missions, functions and tasks required; associated systems/sub-system functionality, and logistic support. They describe the Doctrine, Organization, Training, Material, Leadership and Education, People, and Facilities (DOTMLPF) and their relationship in term of information flow and the technical standard required supporting the missions. Architecture uses can include, but are not limited to, effectiveness analysis; developing requirement and derived requirement documents; conduct interoperability reviews; system development and integration; and resource management.

The best tool to use for effectiveness analysis is a simulation model. For legacy products, a simulation model often exists. Well-constructed simulation models are useful for parametric type analysis to determine the effect of varying the attributes being used in a trade-off or for analyzing the physical solution (alternatives or preferred) based on applicable design parameters.

For larger legacy systems, virtual reality models are more useful for form and fit type trade-offs and, depending on related algorithms, for determining functional performance and cost.

For new systems or products, mathematical models may need to be created before a simulation model is applicable.

Caution is needed when using effectiveness measures and their models. It must be recognized when the outcome of system effectiveness is uncertain. Obtaining trustworthy relationships among the system performance and system effectiveness is often difficult. Models often only treat one or two of the parameters at a time; supporting models may not have been properly integrated; data are often incomplete or unreliable, and assumptions may not be valid. Thus, results from trade-off analyses using such models and measures may only express relative effectiveness of alternatives within the context of the trade-off analysis.

A valid effectiveness model should provide trustworthy relationships between the underlying performance and technical attributes involved and the system effectiveness measure of interest. The effectiveness measure and its measurement model must be tailored to the maturity of the system design. As the system design and operational concept mature, effectiveness estimates should mature as well.

References

Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

MIL-STD-499B, *Systems Engineering*, October 1993 (not formally approved by OSD), section 4.3.4.2 and 5.5.

Engineering Complex Systems with Models and Objects, David W. Oliver, et al, 1997, Chapter 6 includes a discussion of effectiveness measures and models related thereto.

Systems Engineering Guidebook, James N. Martin, 1996, Section 7.4 includes discussions and models for performing system and cost effectiveness analyses.

Systems Engineering Management, James Lacy, 1992, Part II includes specialty engineering considerations for effectiveness analyses.

System Engineering Planning and Enterprise Identity, Jeffery O. Grady, 1994, Part II, Section 6 includes discussions on specialty integration considerations that help in doing effectiveness analyses.

Models and Simulations: ***DAU Program Manager's Tool Kit*** includes a discussion of the classification of models and simulations.

Virtual Prototyping – Concept to Production, DSMC, Report of the 1992-1993 Military Research Fellows, Chapter 3 includes a discussion of the spectrum of synthetic environments with listings and descriptions of models.

Metrics and Measures

Technical Performance Measurement (TPM) – used to track progress toward achieving a critical parameter related to the system. The critical parameter is usually a measure of effectiveness important to the customer in that its failure to be achieved will cause non-acceptance of the system. To classify as a TPM measure, the performance parameter must be a significant qualifier or determinant of the total system, a direct measure of value that can be derived from results of analyses or tests, and a time-based value and tolerance band that can be predicted and profiled for each parameter and substantiated during development and test. The profile is compared with a threshold value which if not attained at the end of development, or if fallen below or above, whichever case is unacceptable for the selected parameter, a Defense Acquisition Board review of the program is mandated.

Measures of Effectiveness (MOEs) are the critical requirements by which the acquirer will determine system acceptance. Therefore, these measures incorporate the following essential system cost and effectiveness metrics:

Capability – a measure of an end product's (e.g., airplane, or missile) ability to perform the tasks for which it is intended in the environments it is intended to operate and with the operator or user level of skill intended, given that the end product is dependable and suitable. The question answered is: Will it get the task done? The end product must be able to complete its task in a full readiness status or in a degraded status. Capability is directly related to the operational tasks the end product is required to do (e.g., destroy target, communicate, move supplies to a designated destination, or obtain required information).

Dependability – a measure of the degree to which an end product is operable and available to perform its required function at any given (random) time, given it is suitable for its intended use. The question answered is: Will the end product be available and operate when and for as long as needed? Dependability can be a function of the system's ability to survive in the environment it is used; its vulnerability to external threats such as misuse by operators, destructive forces or electromagnetic environments; aging degradation (wear out); and its maintenance status, readiness status, usage rates, durability, mobility, flexibility, and repairability; or a failure within the product before it completes its task.

Suitability – a measure of the degree to which an end product is appropriate for its intended use. The question answered is: Is it the right end product for the task? Suitability involves having the right non-operational attributes designed into the end product – interoperability, compatibility, deployability, transportability, usability, supportability, and maintainability. In addition, an end product has to interface correctly with other products, with operators and within the internal and external operating environments. Enabling products also need to be in place and implemented when needed by the operational end product. Enabling products include: appropriate training curricula, facilities and manuals; packaging, handling and storage provisions; facilities and processes for proper disposal of product parts, especially hazardous materials at the end of useful life of a product and hazardous wastes during product use; and the production, test, operational, maintenance and support facilities, equipment, tools, and manuals. The end products with these sets of enabling products make up the system of interest for a system effectiveness analysis.

Cost effectiveness – a measure of the suitability, dependability and capability added by an end product and its enabling products as a function of total ownership costs. The question answered is: Is the system affordable? Several total ownership cost measures are used:

- Unit cost – the cost of the delivered end product as a function of management, hardware, software, non-recurring start-up, and allowance for change cost. (Also known as "flyaway cost").
- System Cost – the unit cost plus technical data, publications, contractor services, training and support equipment, and factory training.
- Procurement cost – the system cost plus the cost of initial spares.
- Acquisition cost – the procurement cost plus RDT&E and facility construction.
- Life cycle cost – the acquisition cost plus operations, support (including post-production support), and disposal costs.
- Total ownership cost – the total cost to the owner over the life of the end product. This includes the procurement cost for the end product and all related costs thereafter for deploying, training, using, supporting, maintaining, and disposing/retiring the end product as well as any associated enabling products needed to enable the end product to meet its life cycle functionality. It is equivalent to life cycle cost.

- Cost Estimating Relationships (CER) – used for parametric analysis of costs. Allows use of cost data from other projects for similarity analysis. Examples of CER factors are number of interfaces, complexity of interfaces, type of interfaces, platform, reliability levels, and support factors (local vs. depot, user vs. contractor). (Part of parametric cost estimation technique used during early phases of development.)

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process are used, as appropriate, to: (1) assess each alternative physical solution representation; (2) assist in choosing the preferred physical solution representation; and (3) provide the assessments for trade-off analyses to aid in determining recommended decisions and their effects.

Sub-process 23 – Trade-off Analysis

The developer **shall** perform Trade-off analyses to provide the decision makers (i.e., Program Managers and Engineers) with recommendations, predictions of the results of alternative decisions, and other appropriate information to allow selection of the best course of action.

A Trade-off Analysis may be required at any phase of the overall systems engineering process and at any level within any phase. For example, a Trade-off Analysis may involve comparisons of air platform types, system operational concepts, system designs, subsystem designs, or component selection.

Types of Trade-off processes include (but are not limited to):

Trade-off Analysis Type	Example Description	References
Radar System AOA (Example of a System Performance & Constraints Trade-off Report; relates to System Technical Requirements)	A Trade-off analysis to determine which radar system will best meet Marine Corps requirements.	AIR 4.10 Warfare Analysis Department 'Analysis of Alternatives' Process in the archive of the Research and Engineering Process Website.
Aircraft Trade-off Analysis (Example of a Mission & Operational Trade-off Report; relates to Customer and Stakeholder)	A Trade-off analysis to determine which type of aircraft will provide the best performance for a particular set of navy missions (e.g., turboprop, turbofan, or reciprocating engine powered)	AIR 4.10 Warfare Analysis Department 'Warfare Analysis' Process in the archive of the Research and Engineering Process Website.
Selection of best Contractor Concept for a specific purpose (Example of a Functional Solution Trade-off Report; relates to Logical Solutions)	A Trade-off analysis to determine which Contractor Concept provides the best Cost/Effectiveness for the Navy.	AIR 4.10 Warfare Analysis Department 'Source Selection' Process in the archive of the Research and Engineering Process Website.
Sensor Trade-off Analysis (Example of a Design Synthesis Solutions and Technologies Trade-off Report; relates to Physical Solutions)	A Trade-off analysis to determine which sensor would provide the greatest effectiveness for a missile of a specific design.	AIR 4.10 Warfare Analysis Department 'Analysis of Alternatives' Process in the archive of the Research and Engineering Process Website.

Additional information on performing a Trade-off analysis can be found in the INCOSE SE Handbook, Sections 4.5.1 and 4.5.2.

Preceding Process

Assessment Process
- Sub-process 9: Progress Against Plans and Schedules
- Sub-process 10: Progress Against Requirements

Requirements Definition Process
- Sub-process 16: System Technical Requirements

Solution Definition Process
- Sub-process 17: Logical Solution Representations
- Sub-process 18: Physical Solution Representations

Systems Analysis Process
- Sub-process 22: Effectiveness Analysis
- Sub-process 24: Risk Analysis

The Trade-off Analysis process may be invoked by any of these processes either on a singular or multiple bases, and may be invoked at any phase of the overall systems engineering process.

Inputs

- Trade options and constraints (SP 16, 17, 18)
- Plans and schedules trend analysis (SP 9)
- Requirement trend analysis (SP 10)
- Effectiveness Analysis Report (SP 22)
- Effectiveness Models (SP 22)
- Risk Analysis Report (SP 24)

The trade option is a general trade problem and/or the specific alternatives to be considered. Constraints are things like schedule limitations, cost limitations, and organizations to be involved.

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents. For example, controversial inputs/data may be required to perform a Trade-off Analysis for competing subsystems within a larger system. Using the wrong data in that case may not only lead to wrong conclusions and/or an inferior subsystem/system design, but may have further non-systems engineering ramifications such as a contractor protest or a legal action related to the erroneous Trade-off Analysis results. Before beginning, ensure the trade-off problem definition is complete.

Tasks

The developer should plan and do appropriate tasks to complete this sub-process. The entire study (analysis) has to be done in a rigorous and defensible manner such that it can withstand high and detailed levels of scrutiny. Questions and points of contention must be thought out beforehand. Tasks to consider include (but are not limited to) the following:

a) **Plan trade-off analyses and develop a Trade-Off Analysis Plan of Actions and Milestones (POA&M)** to include:

   - the availability and definition of required resources, execution and data collection requirements, expected outcomes, defined conditions (triggers and rigor), level of importance, objectives, schedule of tasks, and type (formal, informal, judgmental; see Table C.23, **Appendix C**)
   - selection criteria that will determine desirability or undesirability of an option or alternative for example, cost, schedule performance and risk; life-cycle outcomes; -ility concerns (e.g., producibility, testability, maintainability, supportability, and disposability); size, weight, and power consumption; and effectiveness analysis outcomes
   - weighting factors (if applicable) for each selection criterion in order to distinguish its degree of importance
   - models and tools (representative or simulation) to be used in the trade-off analysis
   - analysis to be performed, including sensitivity and metrics by which to compare alternatives
   - options or alternatives to be analyzed.

b) **Perform the Trade-off analysis according to the POA&M, and**:

   1) Do appropriate effectiveness analysis tasks (**Sub-process 22**) to provide a quantitative basis for evaluating options.

   2) Do appropriate risk analysis tasks (**Sub-process 24**) to quantitatively assess the risk associated with each option.

   3) Collect data and analyze it to determine the cost, schedule, performance, and risk effect of each option or alternative.

   4) Evaluate options against selection criteria and weighting factors, and identify and define recommendations (if applicable). Weighting criteria is quantified on the basis of the relative importance level of the associated attribute (e.g., if SPEED is twice as important as RANGE then

the SPEED weighting factor might be 2 and the RANGE weighting factor might be 1 or multiples thereof); often weighting factors are normalized, (e.g., the normalized weighting factors are computer as follows: normalized_weighting_factor(i) =W(I), and W(I)=weighting_factor(i)/Σ (all weighting factors)). Important parameters, relative importance, and quantified weights can be partially or wholly through use of precedent, research, testing, expert opinion, the Delphi technique, and other methods as may be appropriate to the Trade-off Analysis being performed. Weights can also be applied parametrically such that variation of the weighting criteria on results can be studied. Also, sensitivity of a Trade-off Analysis results may be studied by varying or parameterizing the appropriate set of analysis variables.

5) **Produce a Trade-off Analysis Document and Trade-off Study Brief**. The Trade-off analysis documentation includes, at minimum, the following:

- Tasking and Problem Statement/Formulation
- Rationale for Study/Analysis
- Scope of Study/Analysis
- Trade-off Analysis Team Description
- Schedule
- Choices and explanations
- Analysis performed
- Weighting Factors, if applicable
- Resulting order of choices
- Rationale/Explanation for results
- Implications of each choice
- Criteria for Choices
- Alternative-Criteria Matrix

The Alternative-Criteria Matrix is a matrix depicting the alternatives (that are the subject of the trade study) and displaying them in a tabular form versus the criteria for choices to be used in the Trade-off Analysis. E.g.;

	CRITERIA			
ALTERNATIVE	RANGE	PAYLOAD	SORTIE RATE	SPEED
HELICOPTER				
TURBOPROP				
TILT ROTOR				

- Sensitivities
- Utility Curves, if applicable

The desirability of alternatives can be measured quantitatively by defining utility functions. Using the oversimplified example above, such a utility function may be *U=PAYLOAD*SORTIE_RATE*. This utility function would provide a measure of payload delivery capacity/time period. The utility function can be computed and plotted for each alternative to produce a utility curve.

- Conclusions
- Recommendations, if applicable
- Annexes (for applicable required and detailed data).

6) Communicate recommendations and impacts to appropriate decision makers.

c) **Record the outcomes of the Trade-off analysis in the enterprise data repository, including assumptions, details of the analysis, lessons learned, models used, rationale for decisions made, recommendations and effects, and other pertinent information affecting the interpretation of the decision made**. (**Sub-process 12**)

Outputs *(List of sub-processes where output is used may include the originating sub-process. "EXT" indicates it is external, unspecified, and not for a sub-process.)*

All outputs should be archived (SP 12)

- Trade-off Analysis POA&M (SP 23)
- Effectiveness Analysis Request (SP 22)
- Risk Analysis Request (SP 24)
- Trade-off Analysis Technical Report (SP 9, 16, 17, 18)
- Trade-off Analysis Presentation (EXT)

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents.
Trade-off study is complete.
Results are archived.

Next Processes

Assessment Process
    Sub-process 9: Progress Against Plans and Schedules
Control Process
    Sub-process 12: Outcomes Management
Requirements Definition Process
    Sub-process 16: System Technical Requirements
Solution Definition Process
    Sub-process 17: Logical Solution Representations
    Sub-process 18: Physical Solution Representations
Systems Analysis Process
    Sub-process 22: Effectiveness Analysis
    Sub-process 24: Risk Analysis

The results of the Trade-off Analysis will be provided to the invoking process, archiving processes, and other systems engineering processes as determined and deemed appropriate prior to study start.

Agents

Program Management
System Engineering
Analysis

Tools

Analysis:

- Excel with VBA
- Access
- Visual Basic, C
- Warfare & System, subsystem models
- Integrated architecture products

Planning/Documentation:

- Project
- Schedule
- Word
- PowerPoint

References

Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**

- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

Naval Operations Analysis, D Wagner, C Mylander, T Sanders, 1999.

Simulation and Modeling Analysis, M Law, D Kelton, 1981& 1982.

System Engineering Management, James Lacy, 1992.

AIR 4.10 Warfare Analysis Department 'Analysis of Alternatives' Process in the archive of the Research and Engineering Process Website.

AIR 4.10 Warfare Analysis Department 'Warfare Analysis' Process in the archive of the Research and Engineering Process Website.

AIR 4.10 Warfare Analysis Department 'Source Selection Process' Process in the archive of the Research and Engineering Process Website.

Metrics and Measures
Trade-off study completion and acceptance by the appropriate agent.
Adherence to schedule.
Adherence to funding plan.

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process are used, as appropriate, to resolve requirement conflicts during requirements definition; to assess groupings of functions, objects, etc., during definition of logical solution representations; to assess design options and alternative physical solution representations during definition of physical solution representations; to determine progress in satisfying technical requirements; and to evaluate outcomes of verifications and validations.

Sub-process 24 – Risk Analysis

The developer **shall** perform risk analyses to develop risk management strategies, support management of risk, and support decision-making.

Preceding Process
Planning Process
Sub-process 5: Technical Effort Definition
Sub-process 7: Technical Plans
Assessment Process
Sub-process 9: Progress Against Plans and Schedules
Sub-process 10: Progress Against Requirements
Solution Definition Process
Sub-process 18: Physical Solution Representations
Systems Analysis Process
Sub-process 22: Effectiveness Analysis
Sub-process 23: Trade-off Analysis

Inputs
- Risk Management Strategy (including Risk Advisory Board requirements) (SP 5)
- Risk Management Plan (SP 7)
- System Engineering Plan (SEP) or Software Development Plan (SDP) (SP 7)
- Plans and schedules trend analysis (SP 9)

- Requirements trend analysis (SP 10)
- Risk Analysis Request (SP 18, 23)
- Effectiveness Analysis Report SP 22)

The above input techniques define product characteristics, V&V results, and requirement conflicts and issues.

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents.

Tasks
The developer **should** plan and do appropriate tasks to complete this sub-process. These efforts seldom include ‘easy answers,’ so team efforts such as brainstorming and interviews are often employed in this process. Tasks to consider include the following:

a) **Identification of technical risk, and resulting project risk, based on exposure to the probability of an undesireable consequence and the effect of that consequence for each Trade-off analysis option for each physical solution representation**. The Representative for Engineering (NAVAIR’s APMSE) asks other agents (see list later in this requirement) from the Research and Engineering Group to identify technical performance parameters that the system must meet. He in turn asks those agents to identify technical risks. These risks include safety items, technical performance parameters that the system may fall short of and programatic (cost and schedule) constraints that pose challenges to the program.

   Risk Analysis: Software Safety. Software safety risk is a sub-discipline of system safety. Software is deemed safe if it is impossible (or at least highly unlikely) that the software could ever produce an output that would cause a catastrophic event for the system that the software controls. Catastrophic events may include loss of physical property, physical harm, and loss-of-life. The Software Safety discipline refers to a broad class of development and assessment processes that attempt to make software safe. This may include techniques such as fault-tree analysis (FTA), formal methods (particularly those aimed at early life-cycle phases), Petri nets, Failure Modes Effect and Criticality Analysis (FMECA), HAZOP, and impact analysis.

b) **Characterize risks by causes, possible effects or consequences, likelihood of occurrence, options for dealing with risks, how long option is available, and coupling with other risks**. It is usually imposible to quantify the consequence and likelihood of a risk related to a new system. This is in sharp contrast to the insurance industry where actuarials precisely quantify both parameters.

   Tools used to get quantative estimates are schedule network models (consequence), reliability models (likelihood), sensitivity analyses (consequence) and technical performance tracking tools (likelihood).

   In the DAU Program Manager’s Tool Kit, parameters are used to quantify risk based upon semi-quantative decisions. Particular parameters for likelihood and for consequence are presented. When using this method, tailor their parameters for the specific application. When using these criteria, keep the same tailored parameters in characterizing every risk associated with the system.

   An alternative to DAU’s semi-qualitative method is a qualitative “Rubic’s cube” approach. In this approach, the risk management board, with inputs from the appropriate agents, rates the consequence and likelihood of each risk on a one-to-five scale. Again, the same scale must be used for all risks in the system we are characterizing. Depending upon which of the 25 blocks in the five-by-five consequence-likelihood matrix the risk falls, it is high, medium or low. NAVAIRINST 5000.21 is a good reference for this process.

c) **Prioritize risks that would likely cause harm, have the greatest effect on the system, and would require attention in the near term**. In terms of risks that would likely cause harm, the prioritization follows the philosophy of NAVAIRINST 5000.21, *Program/Project Risk Management* and the Hazard Analysis task of MIL-STD-882. From a safety standpoint, this is paramount. From a greatest effect on

the system, there are often risks beyond safety risks. The prioritization of program risks includes cost, schedule, and technical (safety is a subset of technical) risks. This process includes prioritizing all of the risks – considering both likelihood and consequence. The risk management board then places high and medium risks on a watchlist for continued surveillance.

d) **Evaluate ways to avert risk, and determine the cost, schedule, and performance effects on the project**.

e) **Define and implement a plan or approach for averting each significant risk**.

f) **Record the risk analysis outcomes in the enterprise data repository and communicate or use risk findings and impacts**, as appropriate.

Outputs *(List of sub-processes where output is used may include the originating sub-process.)*
All outputs should be archived (SP 12)
- List of risks (SP 24)
- Analyses of Risk Severity (SP 24)
- Risk Summary Worksheet (SP 24)
- Waterfall Charts (SP 24)
- Risk Analysis Report (SP 18, 23)

The Risk Analysis Report includes information such as: Lists of Risks, Analyses of Risk Severity, Watch Lists, Waterfall Charts, and Risk Summary Worksheets. The last is a risk summary displaying all significant program risks on a single Analysis of Severity Chart (Rubic's Cube), and is the output NAVAIR uses the most.

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents.

Next Processes
Control Process
  Sub-process 12: Outcomes Management
Solution Definition Process
  Sub-process 18: Physical Solution Representations
Systems Analysis Process
  Sub-process 23: Trade-off Analysis

Agents
Program Manager, Systems Engineering, Reliability & Maintainability, Systems Development & Integration, Weights, Safety, Software

Typically a program level Risk Management Board manages the risk. That board is comprised of Program Management (1.0) and Systems Engineering. Systems Engineering includes:

> The Representative for Engineering (NAVAIR's APMSE) receives technical inputs from engineers throughout the Systems Engineering department (e.g., Systems Development and Integration, Weights, Reliability and Maintainability, Safety, and Software) and from systems engineers in the systems engineering divisions throughout the Research and Engineering Group. For contracted acquisitions, the Representative for Engineering works closely with the chief engineer, the systems engineer, and the prime contractor to identify, assess and control risk.

Tools
Program Risk Summaries ("Rubic's cubes")
DSMC "Weighted Factors"
Schedule Network Models
R&M Models

TPM Tracking tools
Integrated architecture products

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**

Capability Maturity Model® Integration (CMMI℠), 2001: Risk Management process areas
DAU Program Manager's Tool Kit
DAU Systems Engineering Fundamentals
NAVAIR INST 5000.21 Program/Project Risk Management
NAVSOP-3686
Top Eleven Ways to Manage Technical Risk
MIL-STD-882

Metrics and Measures

- Qualitative Risk Severity (where is it on Rubic's cube)
- Quantitative Risk Factor (DSMC Factors)
- Analog of Nichols Growth Curve (keeping up with mitigation plan) (Availability, Reliability, Capability, etc.)

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process help in problem prevention (i.e., to identify the degree of risk associated with recommended decision alternatives and to support the risk management program).

4.5.2 Requirements Validation Process

Requirements Validation is critical to successful system product development and implementation. Requirements are validated when it is certain that the subject set of requirements describes the input requirements and objectives such that the resulting system products can satisfy the requirements and objectives. The Requirements Validation Process helps ensure that the requirements are necessary and sufficient for creating design solutions appropriate to meeting the exit criteria of the applicable engineering life-cycle phase and of the enterprise-based life-cycle phase in which the engineering or reengineering efforts occur.

The five sub-processes associated with the Requirements Validation Process are shown in Figure 4.5.2a.

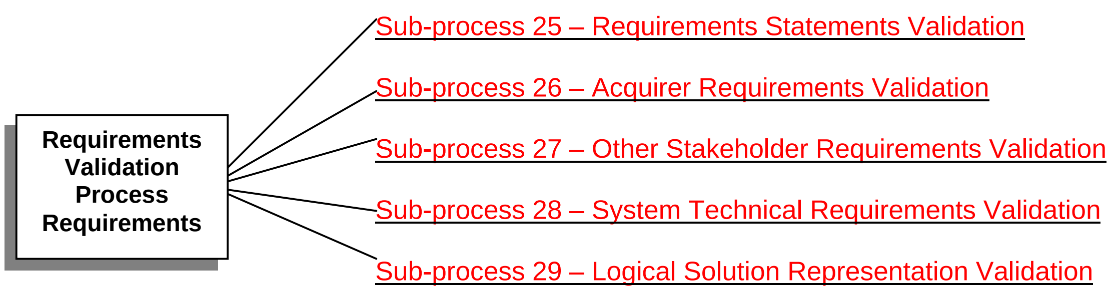


Figure 4.5.2a – Requirements Validation Process/Sub-processes

One or more of these five sub-processes are invoked by a recommended task within either the Requirements Definition Process or the Solution Definition Process. The relationship of the Requirements Validation Sub-processes is shown in Figure 4.5.2b.

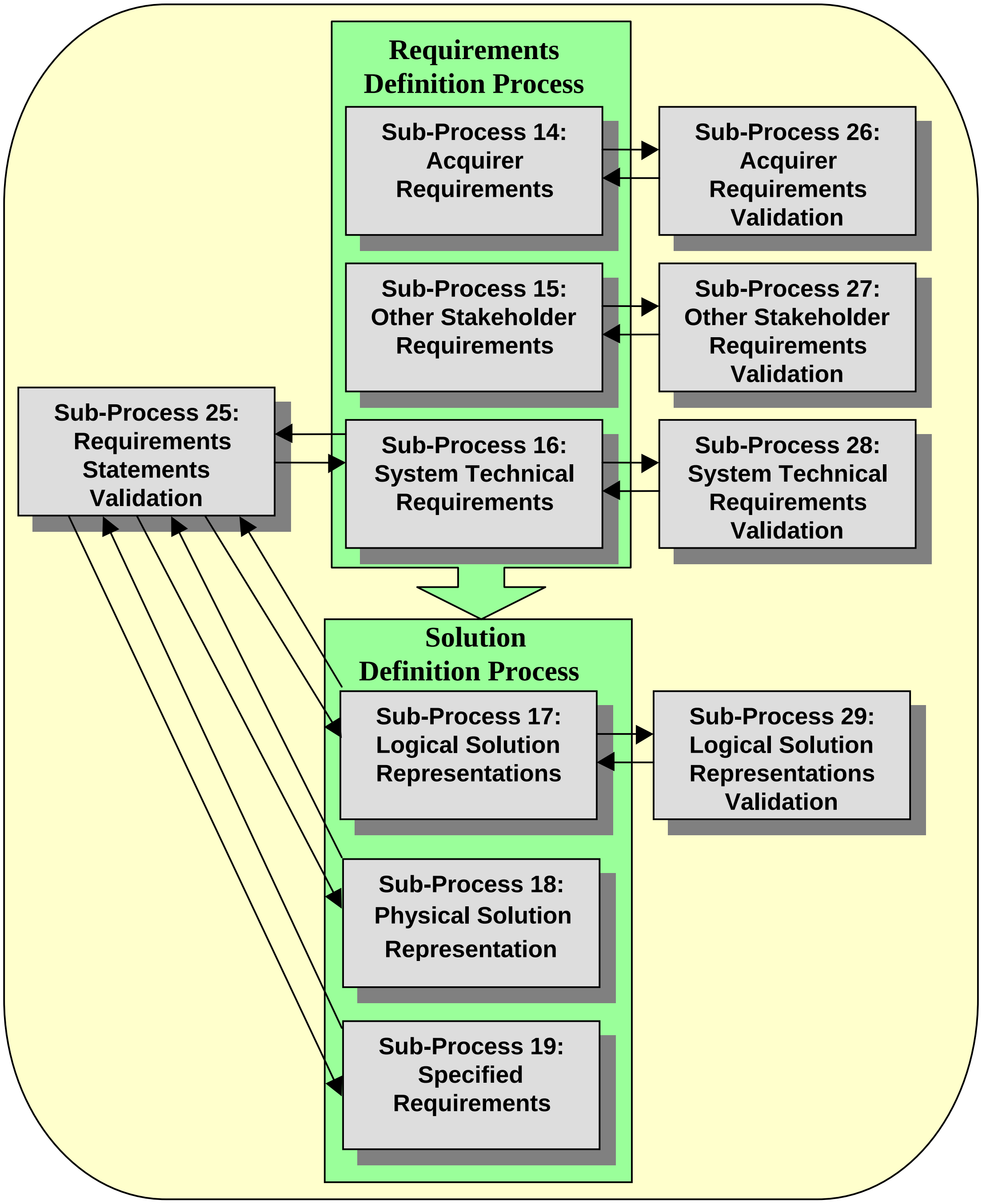


Figure 4.5.2b – Relationship of Requirements Validation Sub-processes

This Guide separates requirement validation into two areas. The first area is the statement validation and the second is the requirement validation. **Sub-processes 16** through **19** define contractual requirement statements (acquirer, other stakeholder, or derived), therefore they all call out **Sub-process 25** to validate the statements (ensuring that they are stating the appropriate intent). Sub-processes 14 and 15 do not produce requirement statements to be imposed on contract and therefore the statements are not so closely scrutinized. Sub-processes

14, 15, 16, 17 call out Sub-processes 26, 27, 28, and 29, respectively, to validate the requirement that is being defined for the system. **Sub-process 19** does not have a requirement validation process because it is a derivative of the other sub-processes.

Requirements **should** be validated at each level of the system structure for requirements definition. Generally, validation of requirements at higher levels is a basis for validation at lower levels (see Section 6).

Sub-process 25 – Requirement Statements Validation

The developer **shall** ensure that technical requirements statements and specified requirements statements, individually and as sets, are well formulated. This is validation of the language of the statements rather than the content.

Preceding Process

Planning Process
  Sub-process 7: Technical Plans
Requirements Definition Process
  Sub-process 16: System Technical Requirements
Solution Definition Process
  Sub-process 17: Logical Solution Representations
  Sub-process 18: Physical Solution Representations
  Sub-process 19: Specified Requirements

Inputs

- Verification Plan (including verification matrix) (SP 7)
- Validation Plan (SP 7)
- System technical requirements (SP 16)
- Derived technical requirements (SP 17, 18)
- Specified requirements (SP 19)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents.

Tasks

The developer **should** plan and do the appropriate tasks to complete this sub-process. The tasks below are broken down into task a) which will be accomplished on each requirement statement individually; and task b) which involves looking at the requirement statements in various combinations and then as a whole. Tasks to consider include the following:

a) **Analyze each requirement statement from** Sub-processes 16**,** 17**,** 18**, and** 19 **to ensure**:

1) **ability to preserve competitiveness** – permits preservation of a competitive stance and is only as constraining on competitive stance as is justified by benefits delivered by requirement.
2) **clarity** – requirement statement is readily understandable without analysis of meaning of words or terms used.
3) **correctness** – requirement statement does not contain an error of fact.
4) **feasibility** – requirement can be satisfied within (1) natural physical constraints, (2) state of the art as it applies to the project, and (3) all other absolute constraints applying to the project.
5) **focus** – requirement is expressed in terms of 'what' and 'why,' or form, fit and function, not in terms of how to develop the products or the materials to be used – detailed requirements that are required to guide detailed design of a product are an exception to this.
6) **implementability** – requirement statement contains information necessary to enable requirement to be implemented.
7) **modifiability** – necessary changes to a requirement can be made completely and consistently.

8) **removal of ambiguity** – allows only one interpretation for meaning of the requirement (e.g., not defined by words or terms such as 'excessive,' 'sufficient,' and 'resistant' that cannot be measured).
9) **singularity** – requirement statement cannot be sensibly expressed as two or more requirements having different agents, actions, objects, or instruments.
10) **testability** – existence of finite and objective process with which to verify that the requirement has been satisfied.
11) **verifiability** – can be verified at the level of system structure at which it is stated.
and
12) **performance based language** **(where appropriate)** – requirement statements cannot give direction on "how to" implement a specific requirement. They need to indicate only the performance and boundary conditions of the requirement.

b) **Analyze requirement statements from** Sub-processes 16**,** 17**,** 18**, and** 19 **in pairs and sets to ensure**:

1) **absence of redundancy** – each requirement is specified only once.
2) **connectivity** – all terms within a requirement are adequately linked to other requirements and to work and term definitions, so that individual requirements relate properly to other requirements as a set.
and
3) **removal of conflicts** – requirement is not in conflict with other requirements or within itself.

c) **Record requirement statements validation outcomes in the established enterprise data repository**.

Outputs
All outputs should be archived (SP 12)
- Requirement statements validation revisions (SP 16, 17, 18, 19)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agent. (Acceptable sets of requirements statements)

Next Processes
Control Process
    Sub-process 12: Outcomes Management
Requirements Definition Process
    Sub-process 16: System Technical Requirements
Solution Definition Process
    Sub-process 17: Logical Solution Representations
    Sub-process 18: Physical Solution Representations
    Sub-process 19: Specified Requirements

Agents
Systems Engineering
Technical Writer

Tools
Requirements Management & System Architecture Database (ex. CORE™, DOORS, SLATE™).

References
Standard across all systems engineering efforts:
- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **C4ISR Architecture Framework**

- **Joint Technical Architecture**
- **FAR/DFARs**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**

MIL-STD-961D
SD-24: General Specification Performance, Design, Characteristics, and Construction of Aircraft Weapons Systems
Joint Services Specification Guides (JSSG)

Metrics and Measures
Percentage of validated requirements statements
Percentage of requirement statements issues

The expected outcomes for these representative tasks are provided in **Appendix C**. The validated technical requirement statements resulting from satisfying this sub-process are used to guide development of system design solutions and evolve into related specified requirements.

Sub-process 26 – Acquirer Requirements Validation

The developer **shall** ensure that the set of defined acquirer requirements agrees with acquirer needs and expectations.

Preceding Process
Planning Process
Sub-process 7: Technical Plans
Requirements Definition Process
Sub-process 14: Acquirer Requirements

Inputs
- Validation Plan (SP 7)
- Acquirer Requirements (SP 14)

Entry Criteria
Inputs have been approved by the appropriate agents.

Tasks
The developer **should** plan and do the appropriate tasks to complete this sub-process. The tasks of this sub-process are completed to ensure both the correctness and traceability of the Acquirer Requirements. Tasks to consider include the following:

a) **Select the methods and define the procedures for validating that the set of acquirer requirements from** Sub-process 14 **is consistent with the level of system structure, enterprise-based life-cycle phase, and Validation Plan, as appropriate**. The method may be via computer or by hand, and may incorporate integrated architecture products, spreadsheets and/or databases.

   Consideration should be given regarding the use of software (such as CORE™ and SLATE™) applications for requirements management and integrated architecture development to provide a means to trace from requirements to mission, task and operational activities to system functions, to systems, and then on to technical standards. This provides the abililty to assess the impact on operations of shortfalls in sytstems functions, performance, interface, data, installation, or standards.

b) **Analyze and compare the identified, derived, and collected acquirer requirements to the set of defined acquirer requirements, to determine downward traceability**. The methods and procedures selected in task a) above should be applied to create a traceabilty matrix. This information is an

automatically generated output of many of the requirements management and system architecture software applications.

c) **Analyze and compare the set of defined acquirer requirements to the identified, derived, and collected acquirer requirements, to determine upward traceability**. The methods and procedures selected in task a) above should be applied to create a traceabilty matrix. This information is an automatically generated output of many of the requirements management and system architecture software applications.

d) **Identify and resolve variances, voids, and conflicts (orphans)**. Return to **Sub-process 14** to produce more appropriate Acquirer Requirements.

e) **Record validation results in the established enterprise data repository**.

Outputs *(List of sub-processes where output is used may include the originating sub-process.)*
All outputs should be archived (SP 12)

- Validation methods & procedures (SP 26)
- Requirements traceability matrix (SP 26)
- Acquirer requirements validation revisions (SP 14)

Exit Criteria
Outputs have been approved by the appropriate agents.

Next Processes
Control Process
 Sub-process 12: Outcomes Management
Requirements Definition Process
 Sub-process 14: Acquirer Requirements

Agents
Systems Engineering
R&M
Safety
Supportability/Testability

Tools
Requirements Traceability Matrix Format
Requirements Management & System Architecture Database (ex. CORE™, DOORS, SLATE™)

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**

Metrics and Measures
Percent of Acquirer Requirements downward traceable
Percent Acquirer Requirements upward traceable
Percent of assumptions for Acquirer Requirements reviewed and approved
Percent of changed Acquirer Requirements revalidated

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process, when combined with other stakeholder requirements, provide inputs to the definition of system technical requirements (see **Appendix F**).

Sub-process 27 – Other Stakeholder Requirements Validation

The developer **shall** ensure that the set of defined other stakeholder requirements agrees with other stakeholder needs and expectations with respect to the system.

Preceding Process
Planning Process
Sub-process 7: Technical Plans
Requirements Definition Process
Sub-process 15: Other Stakeholder Requirements

Inputs
- Validation Plan (SP 7)
- Other Stakeholder Requirements (SP 15)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents.

Tasks
The developer **should** plan and do the appropriate tasks to complete this sub-process. The tasks of this sub-process are completed to ensure both the correctness and traceability of Other Stakeholder Requirements. Tasks to consider include the following:

a) **Select the methods and define the procedures for validating that the set of other stakeholder requirements from** Sub-process 15 **is consistent with the level of system structure, enterprise-based life-cycle phase, and Validation Plan, as appropriate**. The method may be via computer or by hand, and may incorporate integrated architecture products, spreadsheets and/or databases.

   Consideration should be given regarding the use of software (such as CORE™ and SLATE™) applications for requirements management and integrated architecture development to provide a means to trace from requirements to mission, task and operational activities to system functions, to systems, and then on to technical standards. This provides the abililty to assess the impact on operations of shortfalls in system functions, performance, interface, data, installation, or standards.

b) **Analyze and compare the identified, derived, and collected other stakeholder requirements to the set of defined other stakeholder requirements, to determine downward traceability**. The methods and procedures selected in task a) above should be applied to create a traceabilty matrix. This information is an automatically generated output of many of the requirements management and system architecture software applications.

c) **Analyze and compare the set of defined other stakeholder requirements to the identified, derived, and collected other stakeholder requirements, to deterimine upward traceability**. The methods and procedures selected in task a) above should be applied to create a traceabilty matrix. This information is an automatically generated output of many of the requirements management and system architecture software applications.

d) **Identify and resolve variances, voids, and conflicts (orphans)**. Return to **Sub-process 15** to produce more appropriate Other Stakeholder Requirements.

e) **Record validation results in the established enterprise data repository**.

Outputs *(List of sub-processes where output is used may include the originating sub-process.)*
All outputs should be archived (SP 12)

- Validation methods & procedures (SP 27)
- Requirements Traceability Matrix (SP 27)
- Other stakeholder requirements validation revisions (SP 15)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents.

Next Processes
Control Process
    Sub-process 12: Outcomes Management
Requirements Definition Process
    Sub-process 15: Other Stakeholder Requirements

Agents
Systems Engineering
R&M
Safety
Supportability/Testability

Tools
Requirements Traceability Matrix Format
Requirements Management & System Architecture Database (ex. CORE™, DOORS, SLATE™)

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**

Metrics and Measures
Percent of Other Stakeholder Requirements downward traceable
Percent Other Stakeholder Requirements upward traceable
Percent of assumptions for Other Stakeholder Requirements reviewed and approved
Percent of changed Other Stakeholder Requirements revalidated

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process, when combined with acquirer requirements, provide inputs for defining the system technical requirements (see **Appendix F**).

Sub-process 28 – System Technical Requirements Validation

The developer **shall** ensure that the set of defined system technical requirements agrees with validated acquirer and other stakeholder requirements.

A primary intent is to gage the Quality Assurance of input received from other Requirements. Quality Assurance is achieved through accounting (e.g., requirements tracing), confirming previous assumptions, and ascertaining that all life cycle aspects have been covered.

Preceding Process

Planning Process

Sub-process 7: Technical Plans

Requirements Definition Process

Sub-process 16: System Technical Requirements

Inputs

- Validation Plan (SP 7)
- System Technical Requirements (SP 16) (including Design Information and ICD/CDD revisions)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents.

Tasks

The developer **should** plan and do the appropriate tasks to complete this sub-process. The tasks of this sub-process are completed to ensure both the correctness and traceability of System Technical Requirements. Tasks to consider include the following:

a) **Select the methods and define the procedures for validating that the set of system technical requirements from Sub-process 16 is consistent with the level of system structure, enterprise-based life-cycle phase, and Validation Plan** (plan content to be determined) as appropriate. The accounting method may be via computer or by hand, and may incorporate integrated architecture products, spreadsheets and/or databases.

Consideration should be given regarding the use of software (such as CORE™ and SLATE™) applications for requirements management and integrated architecture development to provide a means to trace from requirements to mission, task and operational activities to system functions, to systems, and then on to technical standards. This provides the abililty to assess the impact on operations of shortfalls in sytstems functions, performance, interface, data, installation, or standards. Performance of the other tasks should include customer participation, and, if appropriate, an independent review.

b) **Analyze and compare the set of validated acquirer and other stakeholder requirements to the set of defined system technical requirements, to determine downward traceability**. The methods and procedures selected in task a) above should be applied to create a traceabilty matrix. This information is an automatically generated output of many of the requirements management and system architecture software applications.

c) **Analyze and compare the set of defined system techncial requirements to the validated set of acquirer and other stakeholder requirements, to determine upward traceability**. The methods and procedures selected in task a) above should be applied to create a traceabilty matrix. This information is an automatically generated output of many of the requirements management and system architecture software applications.

d) **Analyze assumptions made with respect to defining system technical requirements to ensure that they are consistent with the system being engineered**. Review key drivers (e.g., MOE or design

constraints) with the customer to confirm consistency with current objectives and development approach.

e) **Analyze system technical requirements that have been defined as essential for the design effort for other life-cycle considerations for which there is no parent requirement in the set of acquirer and other stakeholder requirements**, to ensure that they are consistent with the system being engineered and other system technical requirements. Examples of life-cycle activities for which parent requirements often do not exist are manufacturing, maintenance, training, or disposal. This task is to ascertain that all life-cycle aspects of the product have been considered and that associated requirements are defined.

f) **Identify and resolve variances, voids, and conflicts** (e.g., omissions and orphans). Return to **Sub-process 16** to produce more appropriate System Technical Requirements.

g) **Revalidate the system technical requirements whenever a requirement change is made that affects the acquirer requirements, other stakeholder requirements, or system technical requirements**.

h) **Record validation results**, including lessons learned, **in the established enterprise data repository**.

Outputs *(List of sub-processes where output is used may include the originating sub-process.)*
All outputs should be archived (SP 12)

- Validation Methods & Procedures (SP 28)
- Requirements Traceability Matrix (SP 28)
- System technical requirements validation revisions (SP 16)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents.

Next Processes
Control Process
Sub-process 12: Outcomes Management
Requirements Definition Process
Sub-process 16: System Technical Requirements

Agents
Systems Engineering
R&M
Safety
Supportability/Testability

Tools
Requirements Traceability Matrix Format
Requirements Management & System Architecture Database (ex. CORE™, DOORS, SLATE™)

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**

Metrics and Measures
Percent of System Technical Requirements downward traceable
Percent of System Technical Requirements upward traceable
Percent of assumptions for System Technical Requirements reviewed and approved
Percent of changed System Technical Requirements revalidated

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process show that the set of system technical requirements has traceability from the set of validated stakeholders' requirements that it is both necessary and sufficient as inputs for the definition of logical solution representations (see **Appendix F**).

Sub-process 29 – Logical Solution Representations Validation

The developer **shall** ensure that the set of logical solution representations agrees with the appropriately assigned subset of system technical requirements.

Preceding Process
Planning Process
Sub-process 7: Technical Plans
Solution Definition Process
Sub-process 17: Logical Solution Representations

Inputs
- Validation Plan (SP 7)
- Logical Solution Representation (SP 17)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents.

Tasks
The developer **should** plan and do the appropriate tasks to complete this sub-process. The tasks of this sub-process are completed to ensure both the correctness and traceability of the Logical Solution Representation. Tasks to consider include the following:

a) **Select the methods and define the procedures for validating that the sets of logical solution representations and derived technical requirements from** Sub-process 17 **are consistent with the level of system structure, enterprise-based life-cycle phase, and Validation Plan, as appropriate**. The method may be via computer or by hand, and may incorporate integrated architecture products, spreadsheets and/or databases.

   Consideration should be given regarding the use of software (such as CORE™ and SLATE™) applications for requirements management and integrated architecture development to provide a means to trace from requirements to mission, task and operational activities to system functions, to systems, and then on to technical standards. This provides the abililty to assess the impact on operations of shortfalls in sytstems functions, performance, interface, data, installation, or standards.

b) **Analyze and compare the set of validated system technical requirements to the set of defined logical solution representations and derived techical requirements, to determine downward traceability**. The methods and procedures selected in task a) above should be applied to create a traceabilty matrix. This information is an automatically generated output of many of the requirements management and system architecture software applications.

c) **Analyze and compare the set of defined logical solution representations, derived technical requirements, and any unassigned system technical requirements** (see the note under **Sub-process**

17, task c) **to the validated set of system technical requirements, to determine upward traceability**. The methods and procedures selected in task a) above should be applied to create a traceabilty matrix. This information is an automatically generated output of many of the requirements management and system architecture software applications.

d) **Analyze assumptions made with respect to defining sets of logical solution representations and derived technical requirements to ensure that they are consistent with the system technical requirements and the system being engineered**. Accomplishing this sub-process is simply ensuring the System Analysis Process (**Sub-processes 22**, **23**, **24**) has been completed.

e) **Identify and resolve variances, voids, and conflicts (orphans)**. Return to **Sub-process 17** to produce more appropriate Logical Solution Representations.

f) **Revalidate the sets of logical solution representations whenever a requirement change is made that affects the acquirer requirements, other stakeholder requirements, system technical requirements, or sets of defined logical solution representations and derived technical requirements**.

g) **Record validation results**, including lessons learned, **in the established enterprise data repository**.

Outputs *(List of sub-processes where output is used may include the originating sub-process.)*
All outputs should be archived (SP 12)

- Validation Methods & Procedures (SP 29)
- Requirements Traceability Matrix (SP 29)
- Logical Solution Representation validation revisions (SP 17)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents.

Next Processes
Control Process
Sub-process 12: Outcomes Management
Solution Definition Process
Sub-process 17: Logical Solution Representations

Agents
Systems Engineering
R&M
Safety
Supportability/Testability

Tools
Requirements Traceability Matrix Format
Requirements Management & System Architecture Database (ex. CORE™, DOORS, SLATE™)

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**

Metrics and Measures
Percent of Logical Solution Representations downward traceable
Percent of Logical Solution Representations upward traceable
Percent of assumptions for Logical Solution Representations reviewed and approved
Percent of changed Logical Solution Representation revalidated

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process provide derived technical requirements and logical solution representations as inputs into the definition of physical solution representations (see **Appendix F**).

4.5.3 System Verification Process

The System Verification Process is used to ascertain that: (1) the system design solution generated by implementing **Sub-process 19** is consistent with its source requirements (selected preferred physical solution representation); (2) end products at each level of the system structure implementation, from the bottom up, (see Section 6) meet their specified requirements; (3) enabling product development or procurement for each associated process is properly progressing; and (4) required enabling products will be ready and available when needed to perform.

NOTE – Verification consists of inspection, reviews, analyses, demonstrations, tests, or service experience applied in accordance with the verification plan.

The three sub-processes associated with the System Verification Process are shown in Figure 4.5.3.

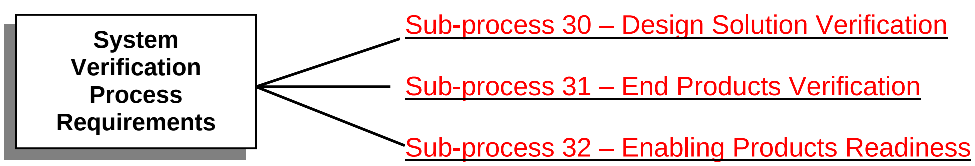


Figure 4.5.3 – System Verification Process/Sub-processes

Sub-process 30 – Design Solution Verification The developer **shall** verify that each end product defined by the system design solution conforms to the requirements of the selected physical solution representation for Hardware and Software (if applicable).

Design Solution Verification methods include inspection, analysis, simulation, demonstration or test of prototypes, mockups, physical models, breadboards, brassboards, etc.

Preceding Process
Planning Process
Sub-process 7: Technical Plans, i.e., the Verification and Validation Plans
Sub-process 8: Work Directives
Requirements Definition Process
Sub-process 16: System Technical Requirements
Solution Definition Process
Sub-process 18: Physical Solution Representations
Sub-process 19: Specified Requirements

Inputs

- Verification Plan (SP 7), including the Verification Compliance Requirement Matrix (VCRM)
- System Engineering Plan (SEP) and/or Software Development Plan (SDP) (SP 7)
- Test and Evaluation Master Plan (TEMP) (SP 7)
- Independent Verification and Validation (IV&V) Plan (SP 7)
- Team Work Plan (TWP) (SP 8)
- Statement of Objectives (SOO) (SP 8)
- Statement of Work (SOW) (SP 8)
- System Technical Requirements (SP 16)
- Preferred physical solution representation (SP 18)
- Specified Requirements (SP 19)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents.

Tasks

The developer **should** plan and do the appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Plan the design solution verification in accordance with the Verification Plan, agreement, applicable enterprise-based life-cycle phase, and to the level in the system structure**. The appropriate level could vary from a system and sub-system down to the component level, and shall include:

   - selection and definition of the appropriate method for design solution verification (which should come from a detailed test plan (SP 7) that describes the methods and processes to be used in verifying compliance against the specified requirements);
   - verification procedures to be followed for the method selected (including the purpose and objective of each procedure, pretest action, and post-test action; and the criteria for determining the success or failure of the procedure); and
   - establishment and checkout (for example, adequacy and completeness) of the environment (for example, climatic conditions, equipment, facilities, and measuring devices, etc.) in which the verification method and procedures will be implemented.

b) **Perform the planned design solution verification using the selection methods and procedures within the established verification environment**, to:

   1) collect and evaluate verification outcomes to either show conformance to the requirements of the selected physical solution representation or to identify variances (unverifiable requirements and constraints); and
   2) resolve variances, as appropriate, and re-verify to establish compliance when the cause of the variance was failure to properly complete the fully characterized design

   Any system requirements that are not controllable and observable shall be reported as an unverifiable requirement to **Sub-process 16** via **Sub-process 25**, but should be confirmed as part of task b) 1) above as well. Variances shall be documented in the Design Solution Discrepancy Reports and/or integrated enterprise data respository for evaluation and resolution.

c) **Reverify according to a redesign verification plan, test method, or procedure when variances were determined to be caused by poor verification or inadequate verification environmental preparation**. The level of regression testing shall depend on the complexity of the design fix and the level necessary to ensure that the redesign has resolved the non-conformance, and been re-addressed in the Test Plan (reference first bullet of task a) above).

d) **Record verification results, including: corrective actions taken; lessons learned; outcomes achieved; Trade-off, effectiveness, and risk analyses completed with resulting key decisions; test**

activities completed; variances; and the verified design solution in the established enterprise data repository. Results should be included in the Redesigned Verification Plan, and shall be an output to **Sub-process 31** (End Product Verification) so that the information can be included in the System Verification process, and to the established enterprise data respository (**Sub-process 12**).

Outputs

All outputs should be archived (SP 12)

- Demonstration Test Readiness Report (DTRR) (SP 12, 31)
- Design solution verification report (SP 31)
- Design solution deficiency and discrepancy reports (hardware and software, if applicable), (SP 10, 11, 12, 19, 31).

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents.

Next Processes

Assessment Process
    Sub-process 10: Progress Against Requirements
    Sub-process 11: Technical Reviews
Control Process
    Sub-process 12: Outcomes Management
Solution Definition Process
    Sub-process 19: Specified Requirements
System Verification Process
    Sub-process 31: End Product Verification

Agents

Manufacturing should identify the approach for duplicating a product configuration in a cost effective manner. The qualification of the manufacturing process must ensure the adequacy of the production planning, tool design, and assembly methods. Configuration Control should be established to ensure that both the production baseline and the production process are controlled and disciplined.

Logistics should include a Part Control Plan, which provides device control with an adequate program set up with vendors to ensure adequate controls. Early detection of parts problems is a key to a low-risk transition to production. The consideration of spares availability for the operational phase should impact system design during the development phase.

Product Assurance – Specialty Engineering:

– Producibility measures the relative ease of manufacturing a product. Manufacturing Plans should be reviewed to ensure that the product does not contain any high risk processes and that the risks are identified and understood.
– Quality Assurance is more than just establishing a good quality inspection system. A management commitment to defect prevention is the prime ingredient of a sound defect control program. A good Quality Assurance program ensures that all Program requirements are satisfied.
– Survivability is a critical part of the design process, which means that the system shall be survivable to the threat levels anticipated in their operating environment. System threats shall be considered and fully assessed as early as possible in the program, usually during System Development and Demonstration.
– Reliability should have advanced that the predicted MTBF (Mean Time Between Failures) is at least 1.25 times the required MTBF. Growth slopes and assigned risk should be integrated into the analysis. +/-3dB is the typical required margin (.707 or 1.414) depending upon the parameter measured; if the system developer cannot meet or exceed this requirement, an analysis demonstrating why a design margin cannot be met shall be provided.
– Maintainability and Supportability. Maintainability is the measure of the ability of an item to be retained or restored to a specified condition or maintainability can refer to the ease of repair and replacement. Supportability refers to the ease of obtaining spare parts, having trained personnel and the ease of testing

the system being supported. Determinations should be based on operational requirements and life-cycle cost considerations.

Software Development shall include a formalized, intensive design effort including verification and validation of the requirements, test plans, and coding. Integrated software/hardware systems shall be tested exhaustively in a total system test bed.

Systems Engineering shall ensure that a process is used to translate operational needs and/or requirements into a system solution that includes the design, manufacturing, test and evaluation, and support processes and products. The systems engineering process shall establish a proper balance between performance, risk, cost, and schedule, employing an iterative process of requirements analysis, functional analysis and allocation, design synthesis, verification, and system analysis and control.

Test and Evaluation (T&E) shall ensure that all end products are tested and evaluated to the full requirements in the Verification Plan and the TEMP. This may include Ranges (land and sea), facilities and laboratories, human factors, aircraft/ship and related systems.

Tools

Modeling & Simulation. Electronic & Mechanical Design Analysis using Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), and Electronic Design Automation (EDA) tools shall be used to verify, validate, and analyze the design for compliance against the requirements.

Stress Testing at above normal loads shall be performed on the system/subsystem/components to ensure that the system can handle stress above the system operational requirements. These above normal loads are increased to determine the system's breaking point; these tests are important for evaluating the robustness of the system and its components.

Software Analysis Tools shall be used to perform an Independent Verification and Validation (IV&V) of the system software processes. A Systems Assessment shall evaluate the requirements, design, testing, and processes of the system design and shall identify risks associated with mission requirements and shall make recommendations for corrective action.

Integrated Architecture products shall be used to verify, validate, and analyze the design for compliance against the requirements.

Requirements Management Tools Summary: http://INCOSE.org/tools/tooltax.html

References

Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**

ANSI/EIA 632 (Para. 4.5.2) Processes for Engineering a System
Capability Maturity Model® Integration (CMMI SM), 2001: Verification process areas
TE000-AB-GTP-010 Parts Derating Requirements and Applications Manual for Navy Electronic Equipment
Equivalent to MIL-STD-2164 Environmental Stress Screening Process for Electronic Equipment
Equivalent to MIL-STD-454 Standard General Requirements for Electronic Equipment
DoD 4245.7-M Transition From Development to Production
NAVSO P-6071 Best Practices – The Transition from Development to Production

Metrics and Measures

Test Schedules (including dates, milestones, etc.) are met.

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process show that: (1) the system design solution appropriately integrates the end products, the enabling products, and the external interfacing products as appropriate to the level of the system structure and enterprise-based life-cycle phase; (2) the functional and performance requirements of the selected physical solution representation are satisfied; (3) the functions of the selected physical solution representation have been implemented correctly; and (4) the system constraints are satisfied, including physical, functional, and human interfaces.

Sub-process 31 – End Product Verification

The developer **shall** verify that an end product ("as built" production representative) to be delivered to an acquirer conforms to its specified requirements.

End Product Verification methods include any and all of the following: inspection, analysis, simulation, demonstration, and ground/flight test of "as built" production representative system.

Preceding Process

Supply Process
- Sub-process 1: Product Supply

Planning Process
- Sub-process 7: Technical Plans

Requirements Definition Process
- Sub-process 14: Acquirer Requirements

Solution Definition Process
- Sub-process 19: Specified Requirements

System Verification Process
- Sub-process 30: Design Solution Definition

Inputs

- End Products ("as built" production representative) (SP 1)
- Enabling products (SP 1)
- Test and Evaluation Master Plan (TEMP) (SP 7)
- Verification Plan (SP 7), including the Verification Compliance Requirement Matrix (VCRM)
- Initial Capabilities Document (ICD) – formerly Mission Needs Statement (MNS) (SP 14)
- Capability Development Document (CDD) or Capability Production Document (CPD) – (formerly Operational Requirements Document (ORD) (SP 14)
- Specified requirements (SP 19)
- Demonstration Test Readiness Report (DTRR) (SP 30)
- Design solution verification report (SP 30)
- Design solution deficiency and discrepancy report (SP 30)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents (approved Test Plan including risk mitigation).

Tasks

The **developer** (either a government test team or in most cases, now, an Integrated Test team, inclusive of the prime contractor) **should** plan and do the appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Plan the end product (system and subsystem, "as built") verification in accordance with the Verification Plan, agreement (normally associated with detailed developmental test plans), applicable enterprise-based life-cycle phase, and level in the system structure.** This shall include:

- selection and definition of the appropriate method for end product (system /subsystem, “as built”) verification (which should come from a detailed Test Plan that describes the methods and processes to be used in verifying compliance against the specified requirements) since methods will be based on platform, or item under test;
- verification procedures to be followed for the method selected (including the purpose and objective of each procedure, pretest action, and post-test action; and the criteria for determining success or failure of the procedure) (*NAVAIR Specific*: Ensure these can be performed in accordance with NAVAIR Instruction 3960.2, Test and Evaluation.);
- establishment and checkout (for example, adequacy and completeness) of the environment (for example, climatic conditions, equipment, facilities, and measuring devices, etc.) in which the verification method and procedures will be implemented; and
- assurance that the test articles are on hand, assembled, or integrated with the verification environment according to verification plans and schedules, and that appropriate sets of specified requirements are available.

Coordination with test ranges, and other testing evaluation and engineering facilities is a must to ensure necessary and satisfactory testing support will be provided when required. Coordination with the prime contractor, facility managers, test squadrons and platform coordinators is absolutely required to ensure test articles are on hand and prepared for test.

For *flight test*, FLIGHT CLEARANCES are required, and the NAVAIR flight clearance process will be followed. Depending upon the system/subsystem under test and circumstances, coordination with test squadron Project Liaison Office is required to ensure appropriate clearance type is obtained.

b) **Verify the end product (system/subsystem, “as built”), using the selected methods and procedures within the established verification environment** (regardless of methodology selected, a common method of documentation for data tracking purposes should be employed) to:

1) collect and evaluate verification outcomes to either show compliance or identify variances (unverifiable requirements and constraints); and
2) (for variances not caused by poor test conduct or conditions) complete appropriate tasks of the Planning Process, the Control Process, the Requirements Definition Process, and the Solution Definition Process to resolve variances, and then repeat this set of End Product Verification tasks. (The generation of deficiency reports, YELLOW SHEETS, White Sheets, and System/Software Trouble Reports, etc., are all used to document variances in the systems/subsystems under test.)

Data collection is determined by the type of tests (flight or facility) being performed. For flight and aircraft ground based testing, the availability of onboard data collection (instrumentation requirements must be coordinated with test and evaluation if existing onboard equipment is not capable of recording test data for the evaluation) and range/facility capabilities (real time telemetry, playback, etc). All laboratory/facility testing must be coordinated with the appropriate lab managers to ensure adequate and satisfactory data collection is available. Data is centrally collected into an integrated enterprise data respository for requirements verification. Any system requirements that are not controllable and observable shall be reported as an unverifiable requirement and reported to **Sub-process 16** via **Sub-process 25** but should be confirmed as part of task b) 1) above as well.

c) **Reverify according to a redesigned verification plan, test method, or procedure when variances are determined to be caused by poor verification or inadequate verification environmental preparation**. Additional testing, as well as regression testing, may be required based on type and magnitude of fixes. (The amount of regression testing required is platform, and system under test, driven.) If variances are caused by poor verification, return to first bullet of task a).

d) **Record verification results, including corrective actions taken; lessons learned; outcomes achieved; Trade-off, effectiveness, and risk analyses completed with resulting key decisions; test activities completed; variances; and the verified end products in the established enterprise data respository.** A test report (the fomat to be agreed upon by both the testing organization and the sponsoring activity) is generated to provide Program Executive Officers and Program Managers with

the appropriate level of engineering information to make educated acquisitional decisions and approve test articles for final operational evaluation or intermediate developmental technical evaluation. *NAVAIR Specific*: Depending upon the specific aviation program, the report is also required to be provided to the Naval Technical Aviation Board (NTAB) per NAVAIR Instruction 3960.2.

Outputs *(List of sub-processes where output is used may include the originating sub-process.)*
All outputs should be archived (SP 12)

- Detailed developmental test plans (SP 31)
- Developmental test methods (SP 31)
- Developmental test procedures (SP 31)
- End product deficiency and discrepancy reports (SP 10, 11, 19)
- Developmental Test / Operational Test (DT/OT) Transition Report (SP 33)
- Report of Test Results with limitations and constraints for Operational Test (OT) (SP 33)
- Operational Advisory Document (SP 33)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agent. (Completion of the Verification phase evaluated results and reported conclusions.)

Next Processes
Assessment Process
Sub-process 10: Progress Against Requirements
Sub-process 11: Technical Reviews
Control Process
Sub-process 12: Outcomes Management
Solution Definition Process
Sub-process 19: Specified Requirements
End Products Validation Process
Sub-process 33: End Products Validation

Agents
T&E
R&M
Systems Engineering
Human Factors
Acquirer
PEO/PM
Operators / Users (for NAVAIR this includes AIR-5.5, OPTEVFOR, Fleet)
Developer / Contractor (Various)

Tools
Ranges (for NAVAIR this is primarily AIR 5.1 / AIR 5.2 with selected other outside organizations for flight test)
Test Plans (system, subsystem, and integrated)
Facilities/Labs (for NAVAIR this is primarily 5.x and 4.x for ground tests; could be developer/contractor)
Aircraft and systems under test, and ALL supporting systems under test
Flight Clearance
Deficiency Database

Integrated architecture products shall be used to verify that the integrated end products meet operational requirements and to ensure that systems/sub-systems, data/information, materiel and services can operate effectively together.

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**

Capability Maturity Model® Integration (CMMI℠), 2001: Verification process areas
NAVAIR Test and Evaluation Instruction 3960.2 series
NAVAIR NTAB Instruction 3960.5
NATOPS Flight and Weapon Systems Manual (for each platform)
Range Safety Operation Guides (for each range operated on)
Test Squadron Standard Operating Procedures (SOPs)
Facility SOPs
U.S. Naval Test Pilot School Flight Test Manual
Software Requirements Specifications
Manufacturer's specifications
SARs / STRs

Metrics and Measures
Deficiencies (Part I, II, III), number and severity

- Specification Compliance, yes/no and why
- TEMP Compliance, yes/no and why
- Mission Relation/Impact, descriptive

Earned Value Management (cost, performance, test completion, ground/lab/flight hours, and data points)
Test Schedule (including deliverable dates, milestones, and LRIP), performance relative to End Product
Deficiency Reports (Software and Hardware)

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process show that the integrated composite of end products: (1) complies to its specified requirements; (2) functions together with other system end products and with interfacing products throughout the performance envelope; and (3) is ready for delivery to the acquirer, in accordance with the agreement.

Sub-process 32 – Enabling Products Readiness

The developer **shall** determine readiness of enabling products for development, production, test, deployment/installation, training, support/maintenance, and retirement or disposal.

This sub-process determines the readiness of enabling products furnished by the developer to support each life-cycle phase of the product.

Preceding Processes
Supply Process
Sub-process 1: Product Supply
Planning Process
Sub-process 5: Technical Effort Definition
Solution Definition Process
Sub-process 19: Specified Requirements

Inputs

- Enabling Products (SP 1)
- List of: Methods and Tools, Facilities, Equipment, Training (SP 5)
- Specified requirements (SP 19)
- Enabling products development projects (SP 19)

  Categories and examples of enabling products:
  - Fleet Assets – fleet-owned assets being modified (ex. Mission computer, radar system, flight control system), operational assets (support aircraft, ship assets, drones, weapon targets, satellites), etc.
  - Development – CAE Tools, Prototypes, Life cycle analysis, Laboratories/Facilities, Requirements Management & System Architecture Database, Software Development Facility, etc.
  - Production – Tooling and Facilities, Manpower, etc.
  - Test – Test Equipment & Software, Verification Plans & Procedures, Test Ranges, GFE, etc.
  - Deployment – Staging Facilities, Warehouses, Shipping Containers, etc.
  - Training – Class Rooms, Flight Simulator, Instructors, etc.
  - Support – Repair Facilities, Diagnostic Equipment, Shipping Services, Staffing, etc.
  - Disposal – Disposal site, Refurbishment Facilities, Removal Tools, Safety Bulletins, etc.

  Further description of enabling products can be found in Section 6.1.1.4 and Appendix F, specifically Figure F.3.

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents.

Tasks
The developer **should** plan and do the appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Plan enabling product readiness determination and associated process proofing** in accordance with the appropriate plan, maturity of related end products, agreement, applicable enterprise-based life-cycle phase, and level in the system structure. Include:

   - selection and definition of the appropriate method for the enabling product readiness determination and for proofing for each applicable associated process;
   - readiness determination procedures to be followed for the method selected, the purpose and objective of each procedure, pre-test and post-test actions, and the criteria for determining the success or failure of the procedure;
   - establishment and checkout (for example, adequacy and completeness) of the environment (for example, climatic conditions, equipment, facilities, and measuring devices, etc.) in which the readiness determination method and procedures will be implemented; and
   - assurance that required information regarding the status and maturity of enabling product development or requirements definition is available, and that non-developmental enabling products are available and, if appropriate, integrated with the environment according to appropriate plans and schedules.

   A comprehensive plan to conduct the readiness review should be developed and agreed-to by the contractor and government. Plan should include resources needed to conduct review, method of establishing contractor's readiness, environment or facilities necessary for the assessment, metrics to ensure mitigation of supplier's risk, and follow-up/corrective action plans.

b) **Do the planned enabling product readiness determination and associated process proofing**, using the selected methods and procedures within the established environment to:

   1) collect and evaluate readiness determination outcomes to either show compliance or identify variances (untraceable requirements and constraints, anomalies, variations, voids, and conflicts); and
   2) (for variances not caused by poor readiness determination, or process proofing conduct or conditions) complete appropriate tasks of the Planning Process, Control Process, Requirements

Definition Process, and Solution Definition Process to resolve variances, and then repeat the readiness determination or proofing.

Readiness Reviews should be conducted to assess risk of enabling products supporting each life-cycle phase of the product. Actions (with milestones) to mitigate risk should be identified in readiness reports to stabilize product configuration and minimize change activity in later phases. Examples of Readiness Review Reports include the Integrated Training Plan, Production Readiness Review Report, Initial Operating Supportability Capability Review Report, and Logistics Support Analysis. Any design, test, manufacturing, logistics, and disposal issue should be identified in the readiness reviews for an effective product development.

c) **Reaccomplish readiness determination** according to redesigned plans, test method, or procedure **when variances were determined to be caused by poor readiness or proofing conduct, or by inadequate environmental preparation**. A follow-up or another readiness review can be conducted if the risk was considered excessive in the orginal readiness review.

Supplier must provide evidence that risk has been effectively mitigated to ensure a smooth transition into the next planned life-cycle phase. After exit criteria has been met and risk has been lowered, the supplier is ready to enter the next planned life-cycle phase.

d) **Record readiness determination and process proofing results**, including corrective actions taken; lessons learned; outcomes achieved; trade-off, effectiveness, and risk analyses completed, with resulting key decisions; test activities completed; variances; **and the verified enabling products and proofing of associated processes in the established enterprise data repository**.

Outputs *(List of sub-processes where output is used may include the originating sub-process.)*
All outputs should be archived (SP 12)

- Enabling Products Readiness Determination (SP 12, 21)
- Enabling Products Readiness Assessment Plan (SP 32)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents.

Next Processes
Control Process
Sub-process 12: Outcomes Management
Transition to Use Process
Sub-process 21: Transition to Use
System Verification Process
Sub-process 32: Enabling Products Readiness

Agents
System Engineering
Logistics
T&E
Training
Manufacturing
Program Manager (PM)

All of these agents for both contractor and government are involved in ensuring the readiness of enabling products.

Tools
Enterprise Data Respository
Integrated Architecture Products
Manufacturing Tooling
TPM Tracking tools/Schedules

Test Equipment & Software
Statistical Process Control
Manufacturing Simulations
CAD/CAM
Removal Tools
Flight Simulators
Training Manuals
Readiness Archives and Databases

These are examples of tools used to ensure readiness of enabling products. This list of tools can become exhaustive depending on the enabling product.

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**

Capability Maturity Model® Integration (CMMI℠), 2001: Product Integration and Verification process areas
DOD 5000.2R, Parts 3.3, 5.2, & 7.4
MIL-STD-1521B
MIL-STD-499B, Parts 5.5 & 5.7
NAVSO P-6071 Best Practices, Sections 5.0, 6.0, 7.0, 9.0, & 10.4
DOD 4245.7-M Transition from Development to Production, Sections 4.0,5.0, 6.0, 8.0, & 9.0
DAU Program Manager's Tool Kit

Metrics and Measures
Adherence to Schedule and Progress versus Plan
Sub-Process Execution Time and Cost
System Definition Detail
Technical Performance Measurement Resolution (Availability, Reliability, Capability, Effectiveness, etc.)
Process Control Matrices

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process show that: (1) associated process requirements for production, test, deployment, training, support, and disposal have been identified; (2) plans and selected methods, procedures, and tools for each associated process will be able to accomplish their intended purpose; (3) enabling product development for each associated process will be completed and enabling products will be available to provide the required support functions to the intended end product; and (4) associated processes are properly proofed (for example, proof test of the manufacturing process for rate production) against requirements and can perform their purpose with respect to support of the intended end product.

> NOTE – For each associated process, enabling products requiring development will go through both design solution verification and end product verification as the processes of this Guide are implemented for that development. Off-the-shelf or reused enabling products will be validated against the acquirer requirements, when appropriate. These non-developmental enabling products will be required for verification of physical and functional interfaces with their related end products during the associated end product verification.

4.5.4 End Products Validation Process

The End Products Validation Process is used to demonstrate that the products to be delivered, or that has been delivered, satisfy the validated acquirer requirements (for example, customer, user, or operator requirements, or assigned requirements) that were input to the system design processes and that are applicable to the resulting end products.

This process is usually interpreted to mean the Operational Test of the system. Not all systems are subject to formal Operational Test (OT), and this process may have to be tailored for these systems. Also, when speaking of software development, the term “validation” takes on a different meaning and is defined in IEEE/EIA-12207. When a software development becomes a major system and subject to OT, this process applies over and above the software definition of “validation”. Operational Testing is usually conducted in phases as part of the life-cycle development of the system. Early testing is usually conducted as an Operational Assessment (OA) and then proceeds through the various OT test periods to OPEVAL and FOT&E.

Sub-process 33 – End Products Validation

The developer **shall** ensure that an end product, or an aggregation of end products, conforms to its validated acquirer requirements.

Preceding Processes

Supply Process
  Sub-process 1: Product Supply
Planning Process
  Sub-process 7: Technical Plans
Requirements Definition Process
  Sub-process 14: Acquirer Requirements
System Verification Process
  Sub-process 31: End Product Verification

Inputs

- End Products (SP 1)
- Enabling Products (SP 1)
- Validation Plan (Operational Test Plan) (SP 7)
- Test and Evaluation Management Plan (TEMP) (SP 7)
- Validation Plan (known here as the Operational Test Readiness Review (OTRR) Plan) (Internal or SP 7)
- Initial Capabilities Document (ICD) – formerly Mission Needs Statement (MNS) (SP 14)
- Capability Development Document (CDD) – formerly Operational Requirements Document (ORD) (SP 14)
- Developmental Test/Operational Test (DT/OT) Transition Report (SP 31)
- Report of Test Results with limitations and constraints for Operational Test (OT) (SP 31)
- Operational Advisory Document (SP 31)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agent. For most programs, the appropriate Development Test (DT) must have been successfully completed and a DT report issued.

Tasks

The developer **should** plan and do the appropriate tasks to complete this sub-process. Tasks to consider include the following:

a) **Determine the type of end product validation required and the exit criteria, including the acquirer requirements applicable to the sytem end products being validated**. This task is usually encompassed in the Operational Test Readiness Review (OTRR). A succesful OTRR will result in a certification message to Commander, Operational Test and Evaluation Force (COMOPTEVFOR) stating that the system is ready for operational testing. This is achieved after review of the CDD,

TEMP, DT Test Report, OT Test Plan and other inputs to confirm that the system will be tested in an appropriate manner against the correct criteria. As necessary, waivers to requirements and limitations to testing must be defined during this task.

> NOTES:
> 1 For a system that is an aggregation of end products (see building block discussion in Subsection 6.1), the individual end products and the aggregation of end products are to be validated.
>
> 2 The types of end product validation include: (1) validation against validated acquirer requirements in the anticipated usage environment with test conditions that span the expected range of actual operating conditions; (2) certification tests against established certification requirements; (3) acceptance tests, using operational processes and personnel in an operational environment; or (4) as specified in the agreement.

b) **Acquire the test article, or aggregation of end products, for the validation as appropriate to the enterprise-based life-cycle phase and level of system structure**. Test articles for OT must be representative of production and are usually procured as part of a Low Rate Initial Production (LRIP) contract. In early phases where an OT is being conducted, the test article may be a prototype or even a model as described below, but any model must be certified by the COMOPTEVFOR. The number of test articles and their configuration need to be planned in conjunction with the Test and Evaluation Management Plan (TEMP). The "test article" should include any support equipment, trainers, or other items necessary to test the article under operationally-representative conditions.

> NOTES – The test article is typically the product, or an aggregation of products, that is to be delivered or that has been delivered and that has already been verified. In early enterprise-based life cycle developments, the product or aggregation of products undergoing validation can be a virtual prototype, breadboard, brassboard, or model. Thus, a detailed simulation, operated so that acquirer perceptions can be evaluated, is a possible means of validation.

c) **Conduct the end products validation in accordance with the Validation Plan, as required in the agreement, to show conformance with appropriate requirements; collect and analyze validation outcomes to identify any variances; and do appropriate process tasks to resolve variances and repeat appropriate verifications and validations**. Actual conduct of the test is the responsibility of COMOPTEVFOR. A final report will document the validation results. Even a successful OT will often list deficiences that need to be corrected at a later time or phase.

d) **Revalidate with improved or corrected procedures and equipment when variances were caused by poor test conduct and conditions**. This task is applicable when the Operational Test Activity has scored the system being validated as "not operationally suitable or effective," and the operational test appears to be flawed for the reasons stated. If the Operational Test Activity concurs, then task c) above should be repeated using correct procedures or equipment.

e) **Record the validation outcomes, procedures, assumptions, lessons learned, and other pertinent information about the validation and results in the established enterprise data repository, to provide traceability**. Leads to **Sub-process 12**.

Outputs *(List of sub-processes where output is used may include the originating sub-process.)*
All outputs should be archived (SP 12)

- Operational Test Readiness Review (OTRR) Plan (SP 33)
- Operational Test Readiness Review (OTRR) certification message (SP 2)
- Operational Test / Follow-On Test & Evaluation (OT/FOT&E) Report (SP 19, 20)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents.

Next Processes

Acquisition Process
    Sub-process 2: Product Acquisition
Control Process
    Sub-process 12: Outcomes Management
Solution Definition Process
    Sub-process 19: Specified Requirements
Implementation Process
    Sub-process 20: Implementation

Agents
OPTEVFOR, DOT&E, Systems Engineering, T&E, COMOPTEVFOR

Tools
Modeling & Simulation (M & S), Hardware In-the-Loop (HIL), Software In-the-Loop (SIL), Flight Test

References
Standard across all systems engineering efforts:

- **DoD 5000 Series**
- **AT&L Knowledge Sharing System (AKSS)**
- **FAR/DFARs**
- **C4ISR Architecture Framework**
- **Joint Technical Architecture**
- **Defense Acquisition University: Systems Engineering Fundamentals**
- **INCOSE Systems Engineering Handbook**

Capability Maturity Model® Integration (CMMI℠), 2001: Validation process areas
DRAFT **MIL-STD-499B** Systems Engineering
NAVAIRINST 3960.2C Test and Evaluation
IEEE/EIA-12207

Metrics and Measures
OTRR is achieved within program schedule.
Operational test procedures and processes are carried out according to the TEMP.

The expected outcomes for these representative tasks are provided in **Appendix C**. The outcomes associated with completing this sub-process provide the end products that conform with acquirer requirements stated in an agreement, including any approved changes, or certification or acceptance criteria, as appropriate.

NOTES

1 The key difference between end product validation and end product verification is that end product validation answers the question: Does the delivered end product conform to the validated input acquirer requirements, certification criteria, or acceptance criteria, as applicable? End product verification answers the question: Does the output end product comply to the output specified requirements from which the end product was built, coded, procured, or assembled and integrated?

2 Processes or manual procedures that are part of the defined solution are implicitly included in this validation, since they are a type of product.

3 **Sub-process 33** addresses the validation of each end product, or aggregation of end products, against validated acquirer requirements. There can be cases where it is also appropriate to validate against other stakeholder requirements.

4 In addition, there can be cases where it is appropriate to validate against actual needs and expectations of end users in their environment under real-world conditions. This is called by various names: market trial, beta testing, or operational test and evaluation.

5 Application context

This section describes the application context for the sub-processes of this Guide. Figure 5 shows external enterprise and project factors that have the potential to affect, or be affected by, project interfaces

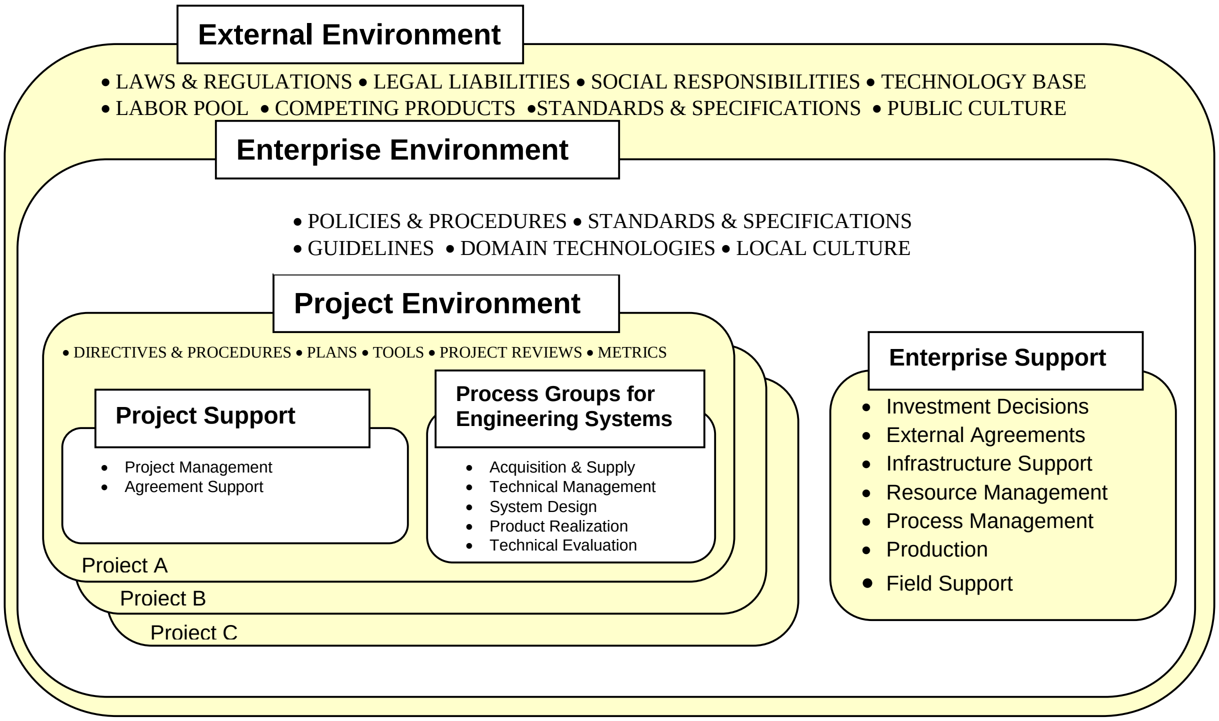


Figure 5 – Context for application of this Guide

5.1 Enterprise factors

The enterprise is the context in which the process requirements of this Guide are intended to be adopted, directed, and implemented. The enterprise is the source of project start-ups and of project cancellations, and is the source of infrastructure and resource support. Enterprises respond to, as well as create, the markets for the system products created by projects within the enterprise. The enterprise further manages the multiple projects within the enterprise to most effectively apply resources and use the infrastructure. The enterprise also establishes constraints of technologies used in existing product lines, as well as manufacturing and test facilities, and support service limitations that constrain project performance.

It is in this context that the enterprise prepares policies and procedures to create or cancel projects, and by which projects perform the processes of this Guide.

5.2 Project factors

5.2.1 Enterprise support

Projects create systems consistent with the business strategy of the enterprise and within the constraint of the enterprise factors cited in Subsection 5.1. Specifically, the following support is to be expected from the enterprise:

a) Investment decision support, including business needs assessments, selection of new start projects, determination of project continuance, and allocation of financial resources for equipment, tools, and training;

b) Agreement support, including contracting, bid and proposal funding, proposal preparation, and oversight (when an external agreement is required);

c) Infrastructure support, including research and development, marketing, facilities, in-service support, computer services, and other services that enable the project to meet its obligations;

d) Resource management support, including financial management, personnel management, training and education of project personnel, office and computer equipment, maintenance, and shipping;

e) Process management support, including establishment of standard procurement processes and methods, guidelines for tailoring adopted processes from this Guide, selection and acquisition of tools, assessment of directed process implementation and monitoring of process effectiveness, and improvement of processes;

f) Production support, including fabrication, construction, manufacturing capacity, and staffing; equipment and tools; and accomplishing fabrication, construction, manufacturing, quality control, and testing;

g) In-service support, including installation, customer support, product upgrades, warranty service, field modifications, on-site consulting, and product certification.

The availability and adequacy of enterprise support functions determine the viability of a project, schedule of project tasks, capability to satisfy an established agreement with another enterprise, and the availability of personnel who have the skills and knowledge to complete project responsibilities.

5.2.2 Project support of the technical process

Projects provide the context in which a system is engineered. Projects use the processes from this Guide as directed by enterprise policies, or as directly adopted by the project, to satisfy agreements. Directives and procedures are prepared by the project to guide both the project management functions and the technical efforts applicable to the specific project. In this context, the technical efforts to meet the requirements of this Guide require project functional support. Such support includes:

a) Agreement support including preparing appropriate tasking agreements between projects, or within the project, to implement the planned technical effort, and providing proposal preparation support, as applicable.

b) Project management including project integration, scope management, time management, cost management, quality management, human resource management, communication management, risk management, and procurement management.

NOTE – More information on the types of support to be exptected is in *A Guide to the Project Management Body of Knowledge* (PMBOK) published by the Project Management Institute.

The availability and adequacy of these project functions, and the project directives and procedures, determine the tasks and scope of the processes for engineering a system. The enterprise determines the tools, equipment, and metrics to be used, and the reporting and management review requirements.

5.3 External factors

The external environmental factors that can affect the processes for engineering a system include local, state, national, and international laws and regulations; potential legal liabilities; social responsibilities; available technologies; the labor pool; competing products and technologies; and national or international standards and

specifications. Also, the processes for engineering a system can be affected by external agreements for upper or lower development projects and requisitioned end products and be existing external infrastructures and the physical world.

Systems and their products operate with organizations and personnel who use the end products, and with other operational entities that provide input to the system, or otherwise interact with the system products, but are not part of the system under development and are not controlled by the developer. The interaction and interfaces (physical or functional) between the system products and their external operational environment can affect the inplementation of the processes used for engineering the project system. Changes in the operational environment can strongly affect system effectiveness and functionality. System performance and adequacy also can be affected by the system's ability to respond both to the operational environment and to changes in the environment.

5.4 Influence of other enterprise projects

Enterprises often have more than one development project at once. Two such projects can sometimes benefit from the exchange of products, for example, parts, subassemblies, or data. Agreements between such projects are established, as appropriate.

6 Application key concepts

This section describes key concepts for application of the processes of Section 4 to the engineering or reengineering of a system. There are two aspects to this section: first, the system to which the processes are applied; and second, the top-down development of system products and the bottom-up implementation and realization of system products. The first is the basis for the system structure; the second is the basis of an engineering life cycle.

6.1 System concept

The system to which the processes of Section 4 are applied consists of both the end products to be used by an acquirer for an intended purpose and the set of enabling products that enable the creation, realization, and use of an end product, to an aggregation of end products. Enabling products are used to perform the associated process functions of the system – develop, produce, test, deploy, and support the end products; train the operators and maintenance staff of the end products; and retire or dispose of end products that are no longer viable for use. Both the end products and the enabling products are either developed or reused, as appropriate. The relationship of these system elements is shown in Figure 6.1.

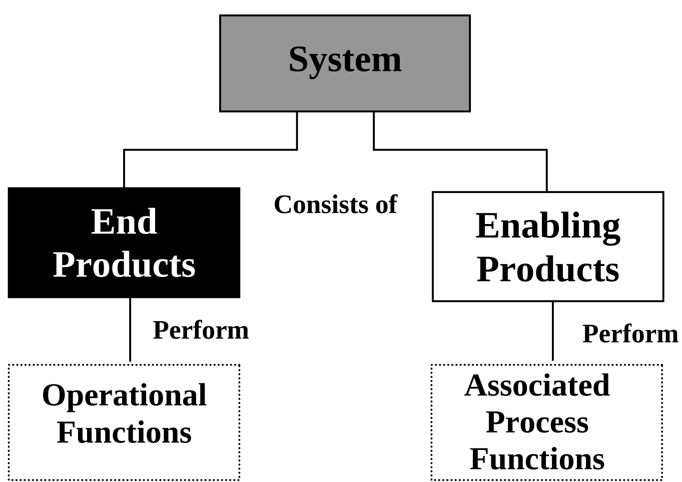


Figure 6.1 – System concept

NOTE – The above system concept implicitly includes the personnel who develop, produce, test, operate, support, and retire the system products, as well as both those who train others involved with these system functions, and the human factors issues and concerns associated with these personnel. Such personnel and human factors issues are included in the application of the processes of this Guide to the building block structure derived from this system concept.

6.1.1 Building block

Ths system forms the basis for a larger structure, called the building block, shown in Figure 6.1.1. The building block provides the framework for application of the processes of Section 4.

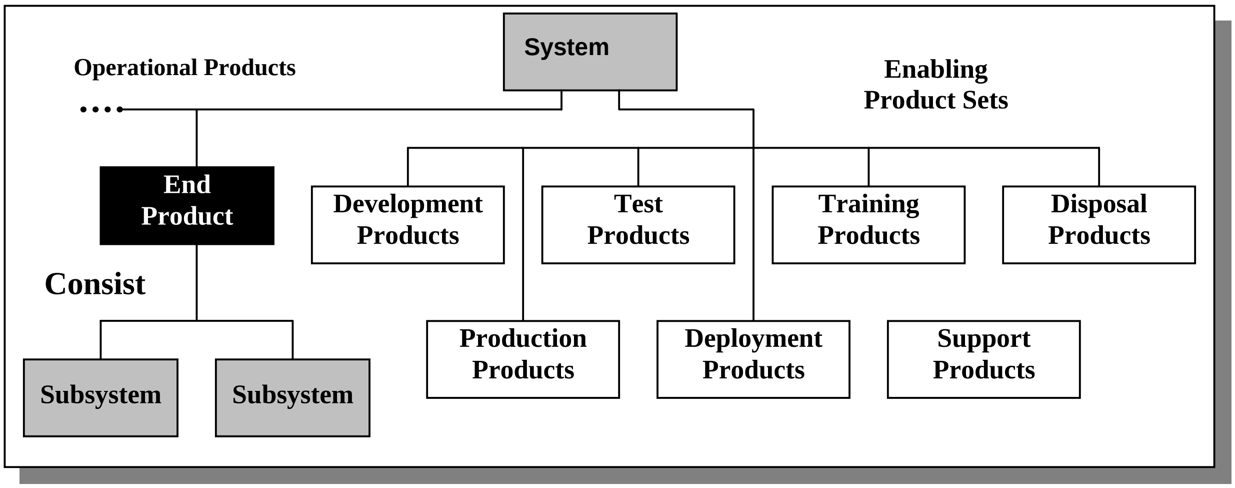


Figure 6.1.1 – Building Block

A building block is made up of the *system* (gray element), one or more end products (black elements), two or more *subsystems* (gray elements) for each end product, and the ensemble of *enabling products* (white elements). Each end product and each enabling product includes one or more of the following; hardware, software, firmware, personnel, facilities, data, materials, services, and processes. The following information can be associated with each element within the building block:

a) configuration identification;

b) the costs to be collected;

c) identification of interfacing elements inside and outside the building block;

d) specifications relevant to the element;

e) definition of work to be done;

f) other relevant agreement information.

6.1.1.1 System element

The *system* element of the building block is the object for which the developer defines the acquirer and other stakeholder requirements using the Requirements Definition Process.

6.1.1.2 End product element

The *end products* perform the operational functions for the system. These products are developed using the Solution Definition Process, are verified against the specified requirements using the System Verification Processs, and are validated against acquirer requirements using the End Products Validation Process.

An end product can be either a legacy product that is being reengineered or a product that the enterprise both has the expertise to make and has similar products already in the market place. Such developments are identified as precedented, derivative, or next-generation. When the specified end product is not *a priori* known, or when the enterprise has limited experience in development of a new system, the development is identified as precedented or as a new concept.

> NOTE – Suppose it is already known that a radio set, a radar, an automobile, or another specific product (including acquirer-furnished equipment) is to be used as an end product. Even though the product type is known (precedented), the specific solution for this next-generation product can be defined using the processes of this Guide to satisfy acquirer requirements.

An end product can be self-contained in terms of its use and operations. It also can be an item that has no use outside a larger end product, but that is developed as an end product of a subsystem (lower-layer system building block) using the System Design Processes.

> NOTES
>
> 1 Examples of self-contained end products are an aircraft, an automobile, a communications satellite, a nuclear reactor, a telecommunication switching module, or a space vehicle that is delivered to an operator.
>
> 2 An end product could also be any of many products that make up a self-contained end product. Examples of such end products are an engine or a radio on an aircraft, a power train or a brake for an automobile, a solar panel, or a transmitter for a satellite, a control panel or a control valve for a nuclear reactor, a switch or a transducer for a telecommunication switching module, or a life support package or a hatch door for a space vehicle. Such end products can be found at the assembly, subassembly, line replaceable unit, component, or part levels of a system.
>
> 3 The end product element is black to represent those elements of the building block that are physically integrated with end products of upper- and lower-layer building blocks to form a composite end product and eventually a self-contained end product.
>
> 4 There can be more than one end product in a building block. In such cases, the system consists of an *aggregation* of end products, plus their enabling products.

6.1.1.3 Subsystem elements

If end products cannot be manufactured or are not off-the-shelf products that can be reused and purchased from another supplier, subsystems of an end product are developed using the processes of this Guide. Each end product that is developed consists of two or more subsystems (gray elements). When a subsystem is developed, another lower-layer building block is established (see Subsection 6.2). The hierarchy of such building blocks is called the *system structure*.

6.1.1.4 Enabling product elements

Enabling products perform the associated process or non-operational functions of the system. The enabling products are varified to be ready to perform their intended functions when required to support their related end product, or aggregation of end products. When each set of enabling products is developed using the processes of this Guide, another building block is formed (see Appendix F, Figure F.3). Development of an enabling product building block is normally initiated after the related end products are fully defined and after the requirements for enabling products are identified. The building block structure for an associated process is

related to only its parent system building block and does not infer development of all products related to an associated process for the entire system structure (upward and downward in the hierarchy of building blocks).

> NOTE – Application of the processes of this Guide to a building block establishes the specified requirements for the items represented by black or gray elements of Figure 6.1.1. However, only requirements (which most often are not valid technical statements) are initially identified and collected for the enabling products. To represent this difference, the enabling product elements are shown in white. The processes of this Guide are then applied to each set of enabling products to obtain validated technical requirements and, ultimately, derived requirements and specified requirements for these enabling products.

Examples of enabling products developed in conjunction with a system are listed Table 6.1.1.4.

Table 6.1.1.4 – Examples of enabling products for each associated process

Associated Process	Examples of enabling products
Development	Development plans and schedules, engineering policies and procedures, integration plans and procedures, information database, automated tools, analytical models, physical models, engineering management personnel, and connecting cables and other interface structures not being developed as separate end products.
Production	Production plans and schedules, manufacturing policies and procedures, manufacturing facilities, jigs, special tools and equipment, production processes and materials, production and assembly manuals, measuring devices, and manufacturing and procurement personnel.
Test	Test plans (including test environment interactions) and schedules, test policies and procedures, test models, mass/volume mockups, special tools and test equipment, test stands, special test facilities and sites, measuring devices, simulation or analytical models, demonstration and scale test models, inspection procedures, and test personnel.
Deployment	Deployment plans and schedules, deployment policies and procedures, mass/volume mockups, packaging materials, special storage facilities and sites, special handling equipment, special trasportation equipment and facilities, installation prodedures, installation brackets and cables, special transportation equipment, deployment instructions, ship alteration drawings, site layout drawings, and installation personnel.
Training	Training plans and schedules, training policies and procedures, simulators, training models, training courses and materials, special training facilities, and trainers.
Support	Support plans and schedules, support policies and procedures, special tools and repair equipment, maintenance asistance modules, special services (for example, telephone hotline and customer access lines), special support facilities and handling equipment, maintenance manuals, maintenance records system, special diagnostic equipment (not an integral part of the end product), and repair personnel.
Disposal	Disposal plans and schedules, disposal policies and procedures, refurbishment facilities and equipment, special disposal facilities and sites, special equipment for disposal of end products, and disposal personnel.

6.1.2 Building block roles

The building block is used for: (1) identifying and assigning specifications for the system, end products, and subsystem elements; (2) managing interfaces; (3) enabling multidisciplinary teamwork; (4) assessing risk; (5) structuring technical reviews; and (6) cost collection and reporting. Data and document management is facilitated by the building block since each system element shows the source of such data and documents. Data and documents are generated as work products or deliverables as a result of the technical efforts to develop each system element. Likewise, each system element has a work package assigned to direct the team doing the planned technical effort.

6.1.2.1 Specifications

Specifications document the specified requirements that are an output from the Solution Definition Process. The building block relationships of black and gray element specifications and the white element requirements, as well as appropriate interface specifications, are shown in Figure 6.1.2.1.

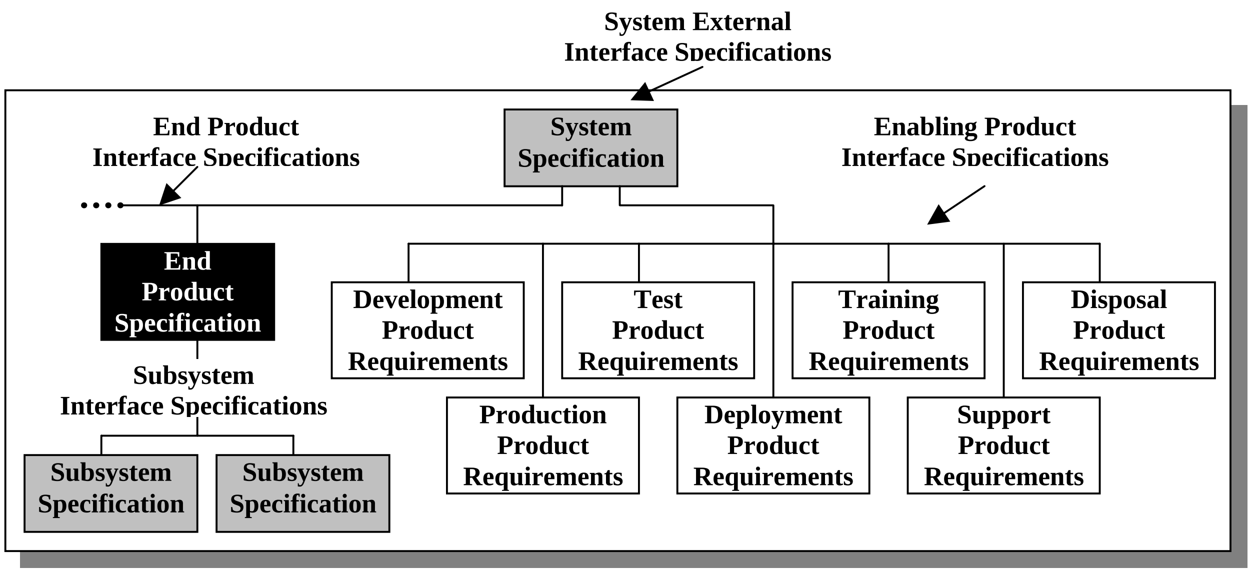


Figure 6.1.2.1 – Building block role – specifications

NOTES

1 The gray elements represent the system elements that will be defined by specifications produced by application of the System Design Process (see Subsection 4.3), but are not delivered as a unit.

2 The system specifications are the basis of developing end product specified requirements and associated sub-processes. Each subsystem specification is the basis for development of the next lower layer building block (see Subsection 6.2).

Specifications describe the required characteristics of end products (black elements) or a group of products (gray elements). Characteristics include:

a) the functional and performance requirements;

b) interface requirements;

c) the environments in which the product(s) is required to perform its functions;

d) physical characteristics and attributes;

e) the basis for evaluating test articles;

f) the methods for verifying compliance;

g) the intenced uses; and

h) enabling product requirements.

6.1.2.1.1 Stages of maturity

The specifications for the system, end product, and subsystem elements evolve through three stages *conceptual, initial*, and *established*. *Conceptual specifications* are used to show feasibility of a higher-level initial specification (e.g., end product) and to record the characteristics of notional products. Conceptual specifications are evolved into initial specifications by application of System Design Processes. Initial specifications are used to direct lower-layer building block developments of subsystems. The initial specifications evolve into established specifications by application of the System Design Processes. Established specifications:

a) enable making valid estimates of work and resources needed for the next lower-layer building block development;

b) provide basis of communication with and among the development team, suppliers, and customers;

c) provide guidance to testers for completing System Verification and End Products Validation Processes;

d) provide basis for negotiation of engineering changes;

e) guide preparation of detailed drawing or software development file design definitions;

f) enable development of lower-layer building block specifications and solution definitions, e.g., drawings, parts lists, and code lists;

g) enable configuration management (control and maintenance) of solution definitions that satisfy technical requirements; and

h) enable the definition of logistics support for spares, replacement parts, training, manuals, maintenance operations, diagnostic tools, and support equipment.

6.1.2.1.2 Performance specifications

Performance specifications are used when it is appropriate to state requirements in terms of:

a) the required results without stating the method for achieving the required results;

b) function (what is to be accomplished) and performance (how well each function is to be performed);

c) the environment in which the product(s) must perform these functions;

d) the interface and interchangeability characteristics; and

e) the means for verifying compliance.

6.1.2.1.3 Detail specifications

Detailed specifications are used when it is appropriate to state design requirements in terms of:

a) material to be used;

b) how a requirement is to be achieved; and

c) how a product is to be fabricated or constructed.

NOTE – Detail specifications are applicable guide creation of detailed drawings or the software development file: pseudocode and software dictionary.

6.1.2.2 Interface definition

Interface specifications are essential in most system development activities to clarify interdependencies between system elements within the buiding block (internal) and other systems above, below, and at the same layer of development (external). Interface specifications are used to define and specify:

a) physical and functional relationships between system elements, including operators;

b) functional requirements resulting from these relationships; and

c) constraints.

6.1.2.3 Multidisciplinary teamwork

Another role for the building block is to enable multidisciplinary teamwork. A reference structure for team assignment is shown in Figure 6.1.2.3. Teams themselves do not ensure teamwork. It is how the teams are integrated that is important, as well as the assignment of properly skilled team members. A system core team is usually composed of the project technical manager, along with memebers to be assigned to team lead positions on end-product and associated process teams. An end-product team can be the leaders from their resprective subsystem team. An enabling product team can be individuals representing their respective functional disciplines. These functional specialists are also assigned to subsystem teams, as appropriate. A subsystem team is normally appropriate domain experts as well as functional specialists and other required specialists. A subsystem team becomes the core team for the next lower-layer building block development of subsystem and end products.

NOTE – As with the application of any complex process, training of all members in the application of the concepts and practices in this Guide is key to its successful application. Successful training includes both training that brings new team members up to speed and training that refreshes existing team members on the currently active elements of the process as the project proceeds.

Multidisciplinary teamwork ensures the accuracy and completeness of the evolving technical data package from which test articles, pre-production prototypes, and production products are to be manufactured or coded.

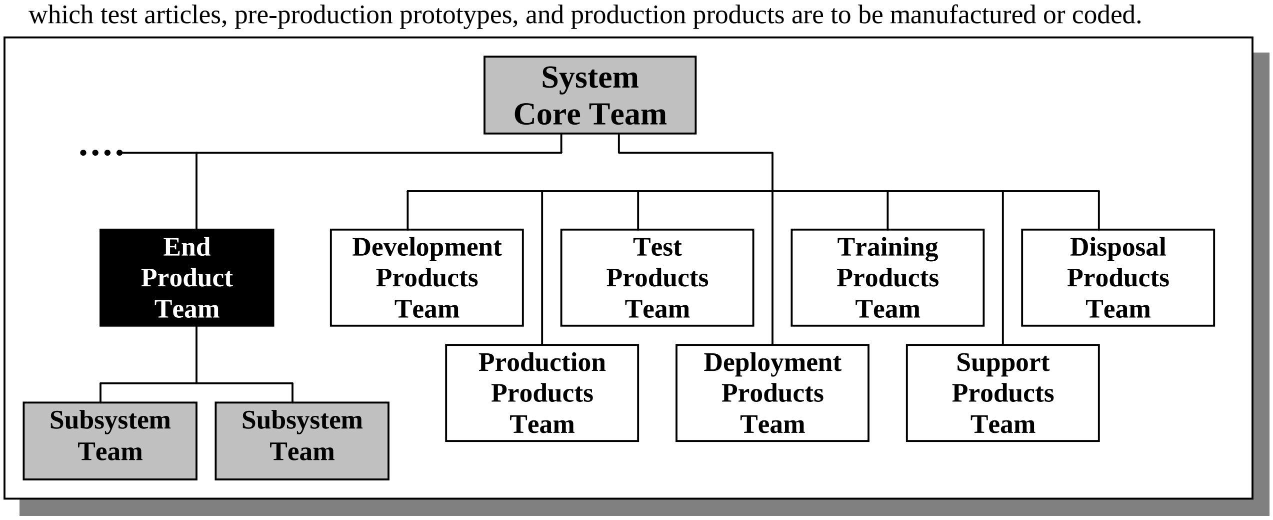


Figure 6.1.2.3 – Building block role - teamwork

6.1.2.4 Risk management

Another role for the building block is to provide a structure for assessing and managing risks. The risk associated with arriving at the solution definition for each end product is a function of the risk assigned to each subsystem of the end product. Likewise, the risk associated with the system of the building block development is a function of the end-product risks and the associated enabling-product risks. The building block shows the relationships between subsystems and end products, and between associated end products that must be considered in determining the risk associated with each end product development. Based on the degree of risk and the relationship among building block elements, risk aversion plans are created and tracked.

> NOTES
>
> 1 Risk depends on the probability of occurrence and its consequences. Risk is potential harm to the project or system under development. Risk is assessed for project, product, and process aspects of the system. This includes the adverse consequences of process variability. The sources of risk include: technical (for example, feasibility, operability, producibility, testability, and system effectiveness); cost (for example, estimates and goals); schedule (for example, technology/material availability, technical achievements, and milestones); and programmatic (for example, resources).
>
> 2 Risk management requires discipline. Risk management is useful only to the degree that it highlights the need for action, and that action leads to the problem being addressed quickly and thoroughly. Moreover, risk management is continuous. Things can go wrong until the last phase of the project is completed.

6.1.2.5 Technical reviews

Technical reviews are scheduled and conducted during each engineering life-cycle phase, as appropriate, to review progress against plan, against the established agreement, and against the applicable enterprise-based life-cycle phase exit criteria. They are conducted to determine whether to continue the investment in future engineering or enterprise-based life-cycle phases based on:

a) the risks and costs associated with lower-layer developments;

b) the maturity of the development to date;

c) if requirements and technical plans being tracked are on schedule and are achievable within existing project constraints;

d) resources required for lower-layer projects; and

e) readiness to proceed, to include external supplier availability and agreement preparations, if applicable.

The building block also is a convenient framework for technical reviews called out in the agreement or the engineering plan. Two types of reviews are conducted – *Incremental* and *System*. *Incremental Reviews* are conducted on subsystems, associated processes for related sets of enabling products, and end products. Upon completion of the incremental reviews a *System Review* (top element of the building block) is conducted. The typical order of these reviews is shown in Figure 6.1.2.5.

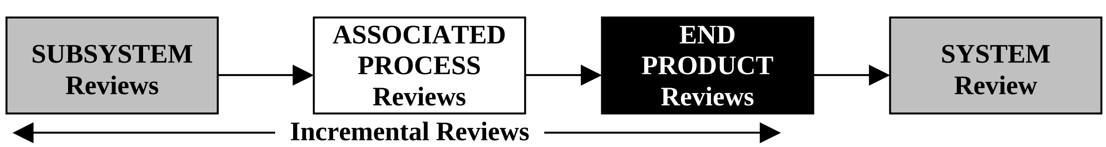


Figure 6.1.2.5 – Building block role – technical reviews

The conduct, the reviewing body, and the presenters of specific technical reviews are planned in a technical review plan during the Planning Process. The team associated with a specific review is assigned the task of creating and presenting the technical review. For *Subsystem Reviews*, the parent end product team is typically the reviewing body. End product team members and team leads selected from other associated process teams make up the reviewing body for the *Associated Process Reviews*. These reviews can be held as a joint review. The core team is the reviewing body for the *End Product Reviews*. Reviewing bodies can be supplemented by other specialists from outside the project, as appropriate to meet technical review objectives. The reviewing body for a *System Review* can be designated in the agreement and/or in the project plan or engineering plan. The *System Review* can be held along with a project review when intended to meet exit criteria for an enterprise-based life-cycle phase.

The purpose of the Incremental and System Reviews are listed in Table 6.1.2.5

Table 6.1.2.5 – Purposes of technical reviews

Review	Purpose
Subsystem	To assess progress in defining and satisfying subsystem requirements.
Associated Process	1) To assess progress and identify issues associated with requirements for one associated process or group of associated processes; 2) to ensure the suitability and availability of the services of enabling products when they are needed.
End Product	To address issues and demonstrate required building block development progress and maturity.
System	See Appendix E.

The technical reviews applicable for the engineering life cycle (see Subsection 6.3) are described in Appendix E. The incremental reviews are to be completed prior to each Appendix E system technical review.

6.1.2.6 Cost collection and reporting

Another use of the building block structure is for collecting and reporting costs related to engineering life cycle activities. The costs are incurred in each building block system element as development activities are done in accordance with assigned work packages generated during planning. The costs incurred include direct labor costs associated with applying engineering process tasks for requirements definition, design definition, design verification, trade-off and effectiveness analyses, fabrication, software bulk copying, technical reviews, data and document generation, integration, and testing.

Technical agreement, planning, and control costs are also collected and reported as a part of the development of associated process enabling products. The costs associated with a building block system development can be easily summarized by rolling up the costs of subsystems, end products, and associated processes. When the project performance is tracked by an acquirer, or for internal control, using a cost performance measurement system, cost and performance measurements are combined using an earned-value approach.

6.2 System structure concept

A single building block rarely defines the complete solution to acquirer and other stakeholder requirements. If a subsystem requires further development, this is done as a subordinate building block development. Lower-Layer building block developments are initiated as soon as definite contents of the building block are determined. The definite contents fo the building block are represented as end product established specifications, initial subsystem specificaitons, interface specifications, and requirements identified for applicalble enabling products of the associated processes. Building blocks are connected to form the system structure, or a building block hierarchy. The relationship among building blocks in a hierarchy is shown in figure 6.2.

This layered approach in the decomposition of building blocks continues until: (1) the end products of a building block can be implemented: (2) the requirements for an end product can be satisfied by an existing product; or (3) the end products can be acquired from a supplier. The specific building block structure will vary with each system, based on the number of end products, the number of subsystems in an end product, and the applicable enabling products of the associated processes.

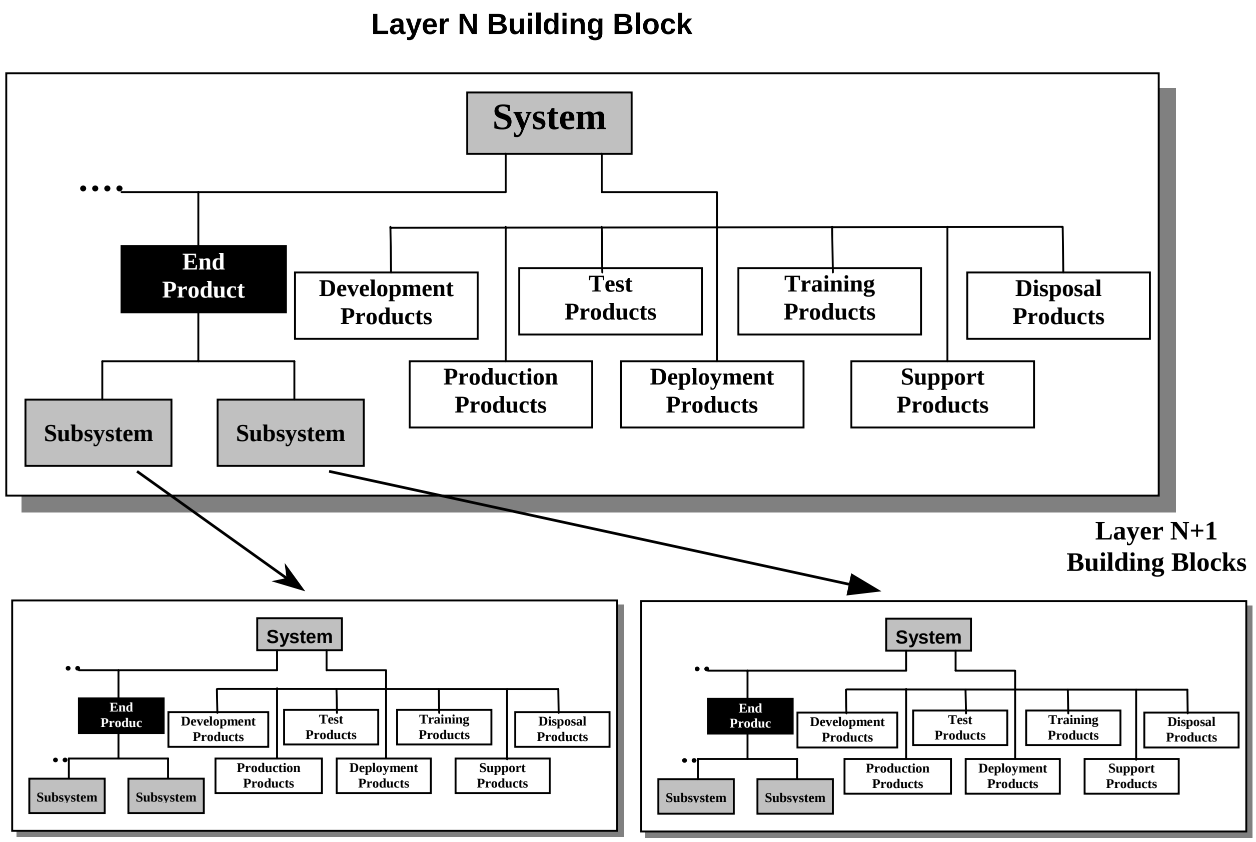


Figure 6.2 – Forming a system structure

NOTE – A system structure serves as the framework for the engineering of a system. Although represented in Figure 6.2 as a one-to-one decomposition, some cases can occur that have multiple inheritances when the same subsystem or end product can be used several places in the system structure.

The specified requirements for a subsystem become the assigned requirements at the next lower layer of development (see Appendix F). Each building block can have other stakeholder requirements that are not related to the requirements that are either assigned from above or directed by users or customers.

6.2.1 Top-down development

Figure 6.2 shows a view of the layered development approach for a project (also known as a program in some domains). Typically, the project receives acquirer requirements in a formal agreement (see Subsection 4.1) and provides reports and delivers products in accordance with the agreement (see Subsection 4.2). Each project can have several lower-layer building block developments. An agreement is used for each lower-layer building block development using requirements assigned from the parent upper-layer building block. Typically, only one engineering plan (see Subsection 4.2) is required for the multiple layers of building block developments within a single project. If an external supplier is used for a lower-layer building block development, a formal agreement is required.

Figure 6.2.1a is an example system structure showing a layered development. The top building block contains the end product that must satisfy the primary user's or customer's requirements. This top building block represents what is often called the prime contractor's project. Two other projects are shown: Project A and Project B. The top building block in each of these projects represents the top layer of development for the respective project, but the second layer for the prime contractor's project. Project A spawns two layers of devlopment, whereas Project B spawns multiple lower-layer building block developments. The lines connecting the layers reflect the specified requirements assigned from a parent building block to its subordinate building block.

NOTES

1. It is recognized that three approaches are practiced to engineer a system --- top-down, bottom-up, and middle-out. The approach in this Guide could be considered both middle-out and top-down. Since the hierarchy of building blocks of Subsection 6.2 starts in a project that could be anywhere in the system structure, this could be considered middle-out.

2. The top-down approach is intended to flow-down requirements so as to ensure satisfaciton of top-layer building block project customer requirements. It is also intended to take advantage of reuse and off-the-shelf items that satisfy assigned requirements in order to lessen development costs and shorten development cycle time. The requirements fo this Guide are based on the top-down approach.

3. A bottom-up approach to development is normally not to be used unless it is ascertained that the requirements of the top-layer building block project system are not affected adversely.

A project applies the System Design Processes (see Subsection 4.3) to each building block in the project boundary to develop the appropriate system, end product, and subsystem development specifications that are defined to satisfy assigned and other stakeholder requiremnts related to a single building block. The products, therefore, do not require further development. Project B's second layer of development has one building block that requires a third layer of development, whereas the specifications of the other building block's end product are satisfied by either an off-the-shelf product or a reuse product. Project B requires five layers of development to complete the downward definition of end products sufficiently so that they can be either built or coded, procured off-the-shelf, or reused. Project B relies on external suppliers for three end products, one at layer three and two at layer five.

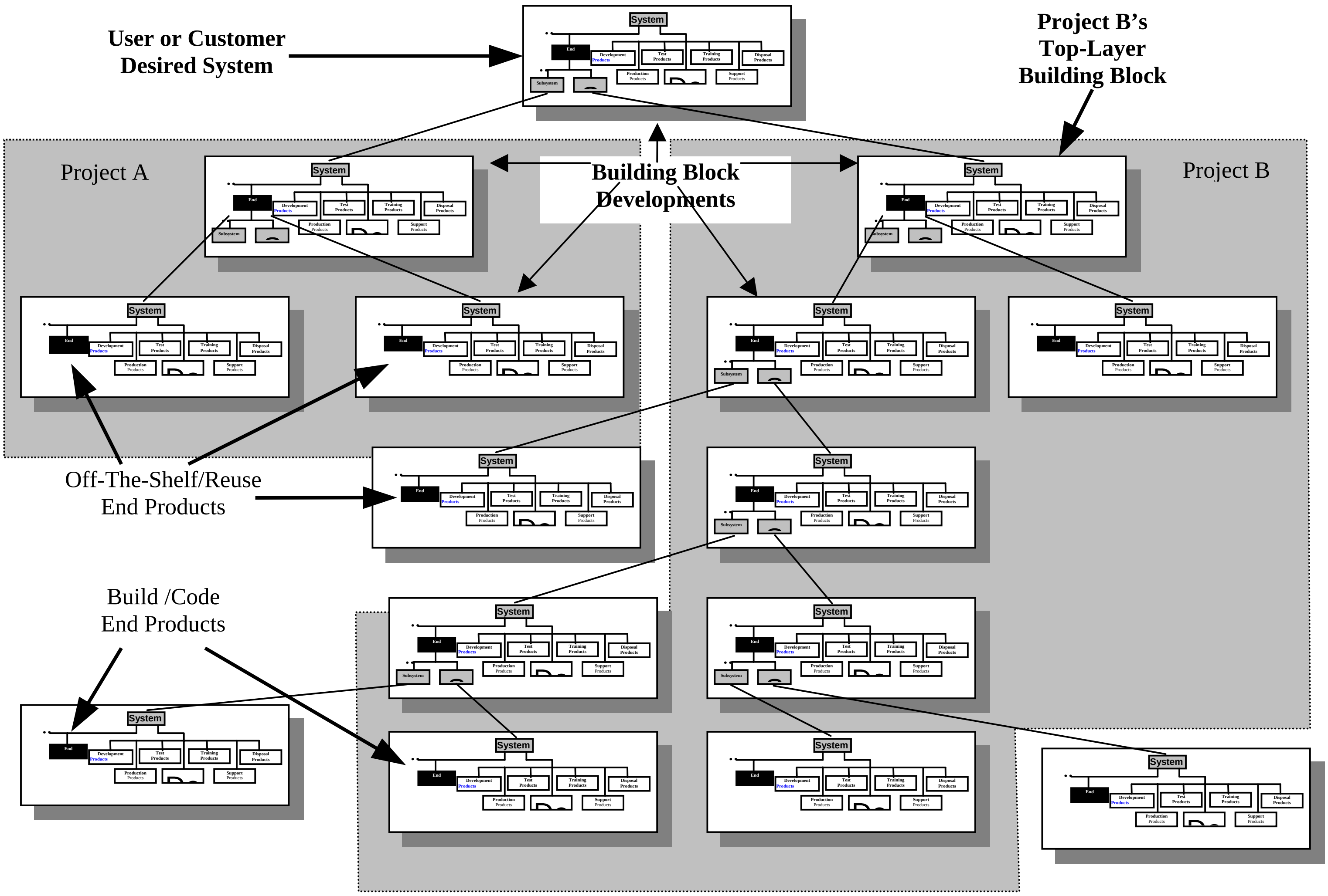


Figure 6.2.1a – Example system structure

Figure 6.2.1b shows, for Project B of Figure 6.2.1a, top-down development using the System Design Processes (see Subsection 4.3). The inputs to each building block include the assigned requirements from the building block above and the other stakeholder requirements that will influence the building block development. The completion of the applicable planned technical efforts on each building block is to result in a set of end product specified requirements and subsystem initial specifications, when further development efforts are required.

The end product specified requirements will be used for End Product Verification, as well as for procurement of off-the-shelf or reuse end products, for building, or for assembly and integration, as applicable. As the technical efforts proceed, design feedback is provided to the parent building block to ensure interface compliance and also to ensure that design decisions do not adversely affect the parent building block end and enabling products, or other subsystems. Likewise, the parent building block provides any changes to requirements that result from other subsystem developments, enabling product developments, or stakeholder changes. Changes are passed downward to lower-layer building block developments, as applicable.

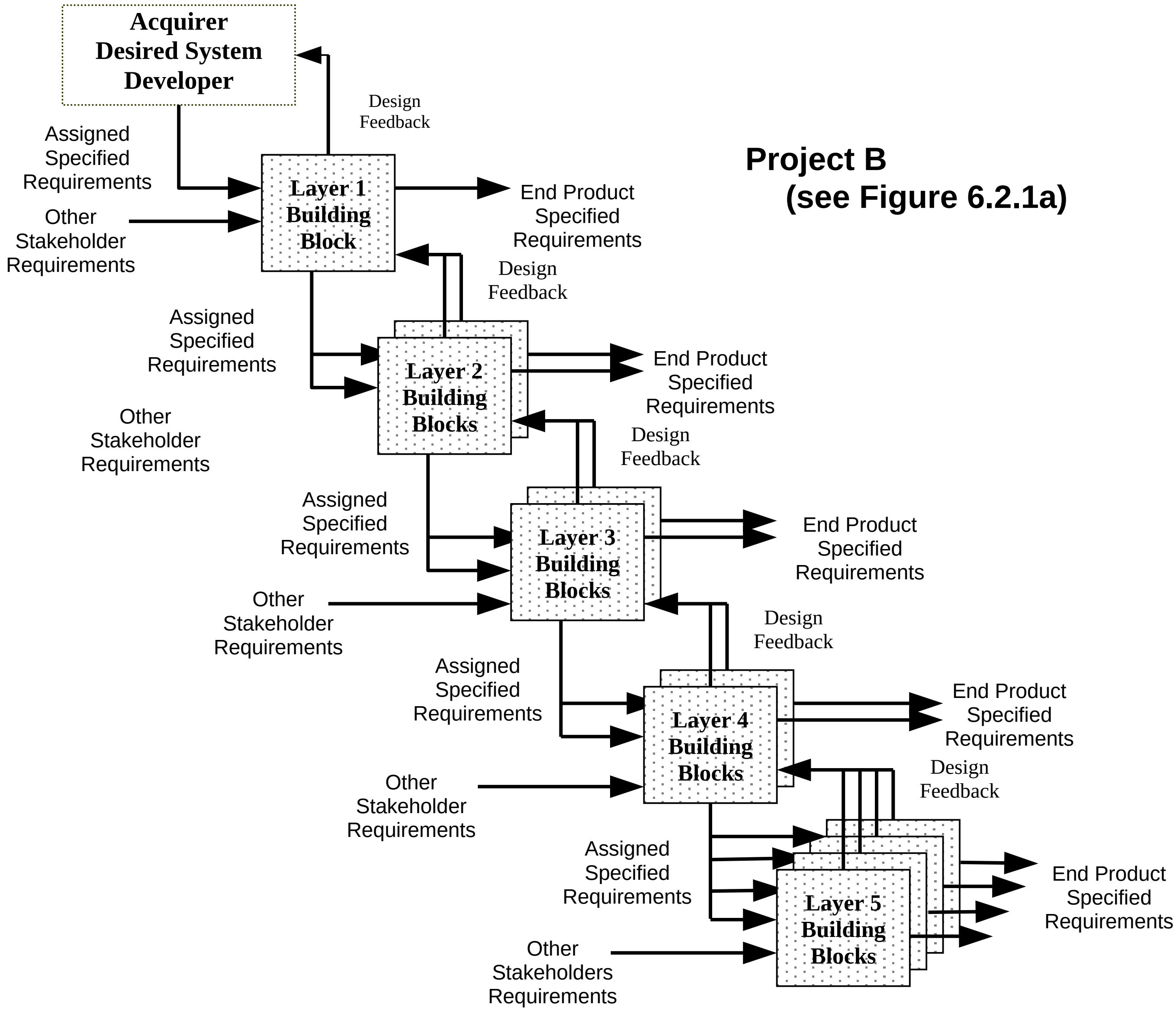


Figure 6.2.1b – Top-down development

6.2.2 Bottom-up realization

The previous subsection explained how end products that make up the system structure are developed, from the top down. Once specific end products are defined sufficiently by specifications so that an off-the-shelf product or a reuse product can be used, or so that the end products can be built or coded, Product Realization Processes (see Subsection 4.4) can be initiated. As was shown in Figure 6.2.1a, this can occur at any layer of the system structure. However, the assembly or integration, verification, and validation of such products occur from the bottom up.

The bottom-up realization of end products is shown in Figure 6.2.2, again for Project B (reference Figure 6.2.1a). The end products procured for layer 5 (built, coded, used off-the-shelf, reused, or delivered by external supplier) are verified using the End Products Validation Process (see Subsection 4.5). Once verified, the end products are delivered, along with verification data, to the parent building block, in accordance with the established agreement. The end product is validated against its assigned requirements, either before delivery by

the end product developer or supplier, or by the layer 4 building block developer. Validation is completed using the End Products Validation Process (see Subsection 4.5) before being assembled or integrated with the other validated end products that make up the appropriate composite end product for the layer 4 building block. This composite end product is then verified, and the procedure is repeated until the project's end product for the layer 1 building block is delivered to the top-level developer in accordance with the agreement.

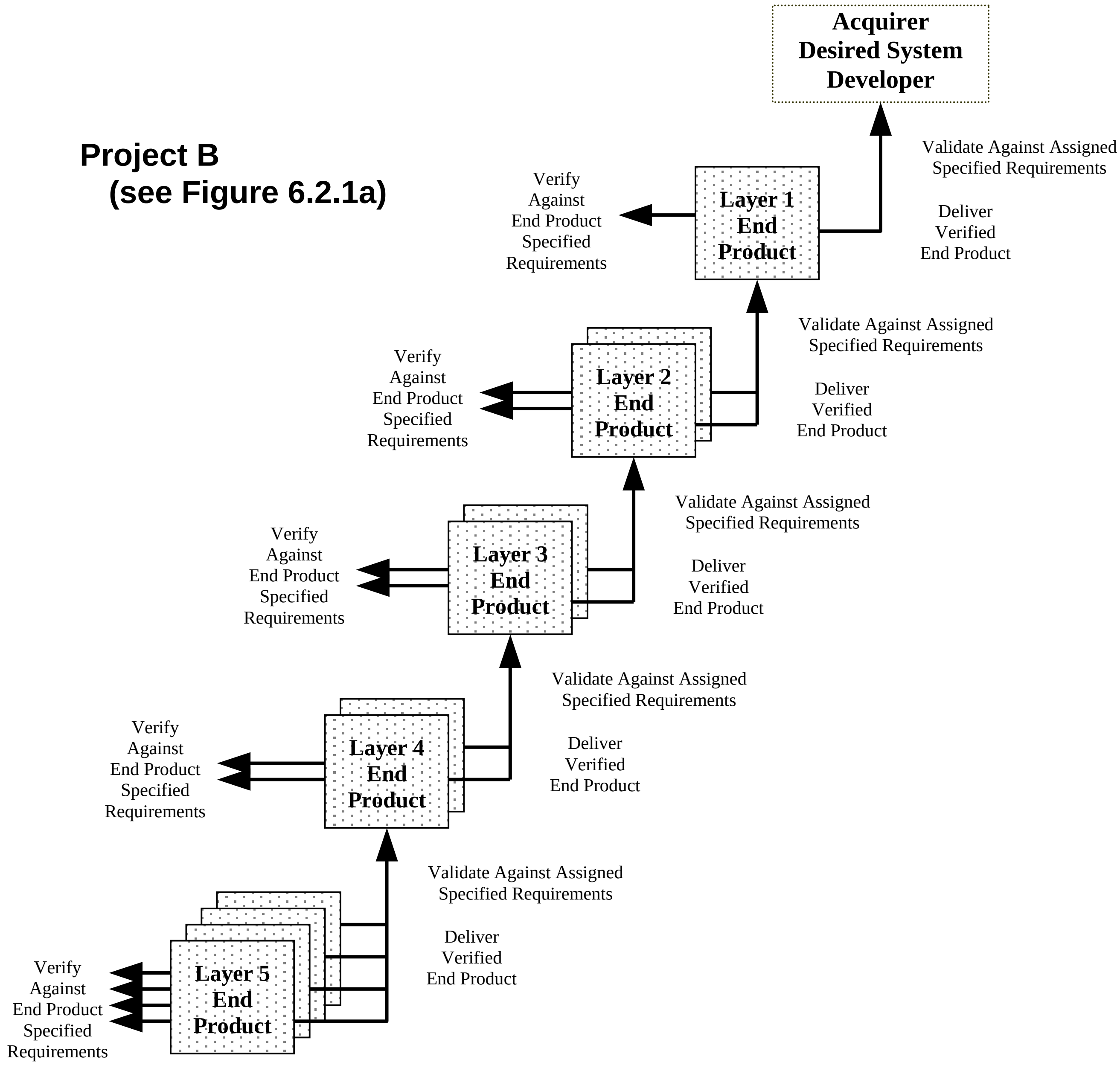


Figure 6.2.2 – Bottom-up realization

A key purpose of this bottom-up approach is to discover test-article variances and design anomalies at the lowest layer of development possible in order to prevent lower-layer end product defects from being buried or overlooked and then showing up during top-layer end product verification and end product, or aggregation of end products, validation. The System Design Processes are applied to the affected building block developments to correct anomalies uncovered by System Verification or End Products Validation Processes (see Subsection

4.5). End products that do not comply with specified requirements must be remanufactured, re-coded, or re-procured to correct the anomaly or deficiency and so that a corrected test article can be verified.

> NOTE—End product validation against acquirer requirements can be accomplished before delivery, but after end product verification is complete, if called for in the agreement. Otherwise, the acquirer validates the delivered end product prior to assembly or integration with other end products to make up the composite end products appropriate to the building block. The aggregation of end products might also need to be validated.

6.3 Engineering life cycle concept

Each product within a system structure has its own life cycle. The product line it represents is developed and produced to meet acquirer requirements and is then inserted into the marketplace either to satisfy an established agreement or through marketing. Following insertion, there is growth stage where the product becomes a viable product in the marketplace. This is followed by a maturity stage where the product is no longer in growing demand, where competitor products take part of the market, or where the product fails to achieve its market potential and demand levels off and starts to decline. Finally, the sales of the product decline, and the product is phased out and is no longer marketed or distributed. All products undergo this life cycle.

> NOTE—The product life cycle is the one generally defined in project management books. This life cycle is the driver for the two other life cycles, in that new products must be developed, or that legacy products are improved, to create new business and profitability to an enterprise, or to keep systems competitive to meet external threats to an enterprise or nation.

The processes of this Guide are applicable at any point in a product's life cycle. In the early stages of a product's life cycle, the processes for engineering a system are applied to bring the system, or a portion thereof, into realization. System products are then produced and transitioned into operations where products are used and supported and during which operators and maintainers are trained. As products are used and as design anomalies or desired product improvements are identified, the processes of this Guide are applied to reengineer the products. Finally, during product retirement, the processes of this Guide are applied to correct any enabling product design anomaly for the retirement or disposal process.

The layers of development shown in Figures 6.2.1a and 6.2.2 are directly correlated with a set of engineering life-cycle phases during which the processes of this Guide are applied. The engineerng life-cycle phases are described in Table 6.3. These phases are grouped as follows: (1) Conception, consisting of the Pre-System Definition Phase; (2) Creation, consisting of the System Definition, Subsystem Design, and Detailed Design phases; and (3) Realization, consisting of the End Product Physical Integration, Test, and Evaluation phase.

Figure 6.2.1a shows application of the phases related to Conception and Creation for the top-down development. Figure 6.2.2 shows application of the phase related to bottom-up Realization. Appendix B describes how these groups of phases are used in individual enterprise-based life-cycle phases to incrementally evolve the system products before implementing the utilization phases of the enterprise-based life cycle, or before continuing the utilization enterprise-based life-cycle phase in which the system products were improved using the activities of the engineering life-cycle phases.

> NOTE—The engineering life cycle applies in the research and development stage of a product's life cycle, but it also applies during any product life-cycle phase or enterprise-based life-cycle phase when it is needed as a result of engineering or reengineering decisions. (see Appendix B)

Table 6.3 Engineering life-cycle phases

PHASE	DESCRIPTION OF ACTIVITIES
Pre-System Definition	This is the start-up phase of the engineering life cycle. The Technical management Processes, as applicable, are applied to plan a technical effort, or refine the technical effort described by existing plans, that is consistent with an established agreement System Design Processes are applied, as appropriate, to the top-layer building block of a project to determine the best system concepts to satisfy acquirer requirements, or to refine a previously selected concept, or legacy system, established in a prior enterprise-based life-cycle phase. A set of initial specifications for the system and selected end products of the system concept is defined, as appropriate, and technology requirements, risks, and other constraints are identified. Before progressing to the next phase, appropriate incremental technical reviews and a system concept review are completed.
System Definition	System Design Processes, and appropriate Technical management and Technical Evaluation Processes, are applied to the top-layer building block of a project to establish specified requirements for the end products and to define initial specifications, including interface specifications, for subsystems of each end product, and to identify enabling product requirements to enable and end product to meet functionality requirements during development, production, test, deployment, training, support, and disposal, as applicable. Identified high technical risk areas are mitigated during this phase. Before progressing to the subsystem design phase, appropriate incremental technical reviews and a system definition review are completed.
Subsystem Design	System Design Processes, and appropriate Technical Management and Technical Evaluation Processes, are applied to the building blocks at the second layer of the project to establish specified requirements for the end products and to define initial specifications, including interface specifications, for subsystems of each end product, and to identify enabling product requirements to enable an end product to meet functionality requirements during development, production, test, deployment, training, support, and disposal, as applicable. Identified high technical risk areas for subsystem end products and enabling products are averted during this phase. Before progressing to the detailed design phase, appropriate incremental technical reviews and a system preliminary design review are completed.
Detailed Design	System Design Processes, and appropriate Technical Management and Technical Evaluation Processes, are applied to the building blocks at the third and lower layers of the project to establish specified requirements and detailed drawings or documents, as appropriate, for the end products and to define initial specifications, including interface specifications, for subsystems of each end product that requires further development, and to identify enabling product requirements to enable an end product to meet functionality requirements during development, product, test, deployment, training support, and disposal, as applicable. Identified high technical risk areas for lower-layer end products and enabling products are averted during this phase. Before progressing to the next lower-layer detailed design effort, appropriate incremental technical reviews and a system detailed design review are completed on the applicable building block elements. When an end product design can be fulfilled by buying, building, or reuse, development of that end product is complete. Prior to progressing to the next phase of the engineering life cycle, test readiness and production readiness technical reviews are completed.
End Product Physical Integration, Test and Evaluation	End products are obtained from suppliers, acquirers (in the case of customer-furnished items), are off-the shelf, or are fabricated, based on completed detailed design specifications, documents, or drawings. The Implementation process, Technical Management Processes, and Technical Evaluation Processes are applied to validate end products obtained, to assemble or integrate validated end products, and to verify that composite end products satisfy specified requirements. The Transition to Use Process is applied to deliver the verified end products to the acquirer of the next layer up in accordance with the established agreement. Then, the implementation Process, the Technical Management Processes, the Technical Evaluation Processes, and the Transition to Use Process are applied, as appropriate, to successive upper-layer building blocks until delivery of the end products and enabling products required in the agreement that establish the project.

Appendix A – Glossary (normative)

For the purposes of this Guide, the following definitions apply:

acquirer: An enterprise, organization, or individual that obtains a product (good or service) from a supplier.

> NOTES
>
> 1 The acquirer can be a customer or user of a desired system product, or can be a developer obtaining a lower layer product in the system hierarchy from another vendor or a developer in the role of supplier.
>
> 2 An acquirer is a type of stakeholder.

agreement: An arrangement, not necessarily contractual, between two parties (an acquirer and a supplier) that defines the tasks to be performed, the items to be delivered, the acceptance criteria to be applied to delivered items, and other requirements affecting the development or procurement of system products.

assign: Designate a function, product, process, or other item as accountable for a particular purpose.

> NOTES
>
> 1 The terms allocate or partition are used in some domains to denote this concept.
>
> 2 The "assign" relationship can be in various forms: a) requirement to function, b) requirement to product or process, c) requirement to interface, d) function to product or process, e) function to external entity (e.g., the operator), or f) requirement to external entity (e.g., external system).

associated processes: Processes that enable one or more end products to be put into service, maintained in service, or retired from service.

building block: A representation of the conceptual framework of a system that is used for organizing the requirements, work, and other information associated with the engineering of a system. An element in the structured decomposition of the system.

configuration management: A management process for establishing and maintaining consistency of a product's performance, functional, and physical attributes with its requirements, design, and operational management information throughout its life. Reference: ANSI/EIA-649.

constraint: (1) A restriction, limit, or regulation imposed on a product, project, or process. (2) A type of requirement or design feature that cannot be traded off.

customer: An individual, organization, or enterprise that: (1) commissions the engineering of a system; (2) is a prospective purchaser of the end products of a system, or portions thereof; or (3) is an acquirer of a product.

deliverable: An item agreed to be delivered to an acquirer as specified in an agreement. This item can be a document, a hardware item, a software item, a service, or any type of work product.

derivative system: A special type of precedented system derived from a previously operational system through the use of major elements, but whose requirements have been modified to meet new objectives.

derived requirement: (1) A requirement that is further refined from a primary source requirement or a higher-level derived requirement. (2) A requirement that results from a design decision for a logical or physical solution representation.

developer: An enterprise or organization that performs the process requirements of this Guide.

development: The action by which a set of requirements is translated into a solution definition for a set of products that satisfy stakeholders.

document: A collection of data, regardless of the medium on which it is recorded, that generally has permanence and can be read by humans or machines.

NOTE—Documentation is an instance of a document or a collection of documents.

effectiveness analysis: An assessment of how well a product associated with an alternative logical, physical, or design solution is expected to perform or operate, given an anticipated usage scenario.

enabling product: Item that provides the means for a) getting an end product into service, b) keeping it in service, or c) ending its service.

NOTE—Enabling products are related to the associated processes: development, production, test, deployment, training, support, and disposal.

end product: The portion of a system that performs the operational functions and is delivered to an acquirer.

end product validation: Confirmation by examination and provision of objective evidence that the specific intended use of an end product (developed or purchased), or an aggregation of end products, is accomplished in an intended usage environment.

NOTES

1 The key difference between end product validation and end product verification is that end product validation answers the question: Does the delivered end product conform to the validated input acquirer requirements, certification criteria, or acceptance criteria, as applicable? End product verification answers the question: Does the output end product comply to the output specified requirements from which the end products were built, coded, procured, or assembled and integrated?

2 End product validation is used to demonstrate that the product developed or purchased satisfies the validated acquirer requirements in the context of its intended use.

3 Validation against other stakeholder requirements, generally, is not required. These requirements generally act as constraints on either the solution or the process by which a solution is generated. Constraints on solutions will show up in specifications to which an end product is built, coded, or assembled, and then verified against. Process constraints will be evaluated during management reviews or in management reports.

4 Validated is used to designate the corresponding status.

end product verification: Confirmation by examination and provision of objective evidence that the specified requirements to which an end product is built, coded, or assembled have been fulfilled.

NOTES

1 End product verification is used to demonstrate that the specified requirements (specifications) generated by the developer and used to build, code, or assemble the end product have been satisfied.

2 Verified is used to designate the corresponding status.

engineering life cycle: A sequence of phases that evolves an instance of a system from a concept to a set of products consistent with the exit criteria established for an enterprise-based life-cycle phase.

engineering plan: The plan for implementing the processes for engineering a system. The engineering plan reflects an integrated technical effort that balances all factors associated with meeting life cycle requirements.

enterprise: The entity that has governance over a set projects, or over organizations in which projects are carried out.

enterprise-based life cycle: The incremental progress of a system from conception through disposal, marked by management-established milestones with assigned exit criteria.

environment: (1) The natural conditions (weather, climate, ocean conditions, terrain, vegetation, dust, etc.) and induced conditions (electromagnetic interference, heat, vibration, etc.) that constrain the design definitions for end products and their enabling products. (2) External factors affecting an enterprise or project. (3) External factors affecting development tools, methods, or processes.

function: A task, action, or activity performed to achieve a desired outcome.

functional requirement: A requirement that defines what system products must do and their desired behavior in terms of an effect produced, or an action or service to be performed.

> NOTES
> 1 An example of a behavior is "system switches from standby mode to run mode;" an example of an effect produced is "cause an alert signal;" an example of an action or service to be performed is "signal opens valve."
> 2 A functional requirement can include the actor that is to perform the function, the function to be performed, and, if appropriate, the object acted upon. In addition, this information can be complemented by a statement of the environment within which the function is performed, the conditions that cause the function to start, the performance requirements associated with that function, and the conditions that cause the function to terminate.

information database: A repository that provides a capacity to maintain work products and outcomes from implementation of the processes for engineering a system in a controlled manner.

> NOTE—This database provides the basis for controlled maintenance of the information needed by the multidisciplinary teams and management to efficiently and effectively accomplish their assigned tasks. It typically contains the requirements, configurations of a system (past, current, and planned), and all analyses and test results. This database allows for traceability, supports the validation and verification tasks, is essential for change management, and provides information to support decision making.

interface requirement: A requirement that defines the conditions of interaction between items.

> NOTES
> 1 Interface requirements include both logical and physical interfaces. They include, as necessary, physical measurements, definitions of sequences of energy or information transfer, and all other significant interactions between items.
> 2 There are interfaces between a system and things external to the system, and between elements within a system. The latter include, but are not limited to, interfaces between the end products and their operators or maintainers, the interfaces between items that make up an end product, and interfaces between an end product and enabling products of the associated processes.
> 3 For example, communications interfaces involve the movement and transfer of data and information within the system, and between the system and its environment. Proper evaluation of communications requirements involves definition of both the structural components of communications (e.g., bandwidth, data rate, distribution, etc.) and content requirements (what data/information is being communicated, why it is being moved among the system components, and the criticality of this information to system functionality).

layer of development: (1) A level of abstraction as it relates to the system structure made up of building blocks. (2) A level of system decomposition.

method: Techniques that support implementation of process tasks.

> NOTE— A method is the "how" of each task. Methods have the following attributes: a) thought patterns or approaches; b) knowledge base; c) rules and heuristics; d) structure and order; and e) notation.

multidisciplinary teamwork: The cooperative application of all appropriate disciplines by people functioning as a team to achieve solutions that balance the contributions of the disciplines effectively.

normative: That portion of a Guide or specification that governs implementation.

NOTE – A standards document usually contains three kinds of material: (1) The standard itself (normative part); (2) explanatory material to help the user understand the standard (informative part); and (3) other material concerning the administration of the standard and the sponsoring organization (administrative part). The explanatory material is contained in Notes or "informative annexes." Conformance to a standard is judged solely on the basis of the normative material in the standards document.

operational scenario: A sequence of events expected during operation of system products. Includes the environmental conditions and usage rates as well as expected stimuli (inputs) and responses (outputs).

performance requirement: A requirement that defines how well the system products are required to perform a function, along with the conditions under which the function is performed.

precedented: An end product that is a legacy product undergoing modification or a product that the enterprise both has the expertise to make and has similar products already in the market place.

process: A set of interrelated tasks that, together, transform inputs into outputs.

product: (1) An item that consists of one or more of the following: hardware, software, firmware, facilities, data, materials, personnel, services, techniques, and processes. (2) A constituent part of a system.

project: A development effort consisting of both technical and management activities for the purpose of engineering a system.

NOTE— For the purposes of this Guide, project and program are synonymous.

prototype: A model (physical, electronic, digital, analytical, etc.) of a product built for the purpose of: a) assessing the feasibility of a new or unfamiliar technology; b) assessing or mitigating technical risk; c) validating requirements; d) demonstrating critical features; e) verifying a product; f) validating a product; g) determining enabling product readiness; h) characterizing performance or product features; or i) discovering physical principles.

requirement: (1) Something that governs what, how well, and under what conditions a product will achieve a given purpose. (2) Normative elements that govern implementation of this Guide, including certain documents such as agreements, plans, or specifications.

requirements validation: Confirmation by examination that requirements (individually and as a set) are well formulated and are usable for intended use.

NOTES

1 See Table C.25 for what constitutes "well formulated."

2 There are five types of requirements validation in this Guide stated in Sub-processes 25 through 29.

risk: (1) A measure combining the uncertainty of reaching a goal with the consequences of failing to reach the goal. (2) The probability of suffering injury or loss.

risk aversion: The act of averting risk. Averting risk can be through various means: mitigation, avoidance, transfer, or acceptance.

risk management: An organized process for identifying and assessing risks, and for implementing means to avoid them or mitigate their effect if they occur.

specification: A document that contains specified requirements for a product and the means to be used to determine that the product satisfies these requirements.

stakeholder: An enterprise, organization, or individual having an interest or a stake in the outcome of the engineering of a system.

NOTES
1 Examples of stakeholders are acquirer, user, customer, manufacturer, installer, tester, maintainer, executive manager, project manager, and all other personnel having a stake in the development or outcome of the engineering of a system. The enterprise as a corporation or agency and the general public are also stakeholders.
2 An acquirer (see definition above) is a specific instance of a stakeholder and is individually acknowledged since the acquirer is a principal in establishing the acquirer-supplier agreement.
3 All stakeholders other than the acquirer are referred to as "other stakeholders".

stakeholder requirement: A requirement that represents what stakeholders of a system need or expect of the system products.

standard: A document that establishes engineering and technical requirements for products, processes, procedures, practices, and methods that have been decreed by authority or adopted by consensus.

subsystem: A grouping of items that perform a set of functions within a particular end product.

supplier: Provides a product (either end products, enabling products, or both) or a group of products to an acquirer. The supplier (external or internal to the acquirer's organization) can be a vendor that has a product that does not need development, or a developer that must develop the desired system product or products.

system: An aggregation of end products and enabling products to achieve a given purpose.

system technical requirement: A requirement derived from one or more stakeholder requirements and stated in technical terms.

technical performance measurement (TPM): The technique of predicting the future value of a key technical parameter of the higher-level end product under development, based on current assessments of products lower in the system structure.

NOTES
1 Involves the continuing verification of the degree of anticipated and actual achievement for technical parameters. Confirms progress and identifies variances that might jeopardize meeting a higher-level end product requirement. Assessed values falling outside established tolerances indicate a need for evaluation and corrective action.
2 Key characteristics of TPM are:
a) *Achievement to Date*—present achieved value of the technical parameter based on estimates or actual measurement;
b) *Current Estimate*—the value of the technical parameter predicted to be achieved by the end of the technical effort with remaining resources (including schedule and budget);
c) *Technical Milestone*—a point where TPM evaluation is accomplished or reported;
d) *Planned Value Profile*—the projected time-phased achievement projected for the technical parameter from the beginning of the development or as replanned as a result of a corrective projection;
e) *Tolerance Band*—an envelope containing the Planned Value Profile and indicating the allowed variation and projected estimation error;
f) *Objective*—the goal or desired value at the end of the technical effort;
g) *Threshold*—the limiting acceptable value that, if not met, would jeopardize the project;
h) *Variation*—the difference between the planned value and the achievement-to-date value.

technical review: An event at which the progress of the technical effort is assessed relative to its governing plans and technical requirements.

test article: An item built, constructed, coded, or otherwise implemented, for checking conformance to specified requirements or for checking validation against acquirer requirements for the item.

traceability: The ability to identify the relationship between various artifacts of the development process, i.e., the lineage of requirements, the relationship between a design decision and the affected requirements and design features, the assignment of requirements to design features, the relationship of test results to the original source of requirements.

unprecedented: A specific end product that is not known *a priori*, or the enterprise has limited experience in developing this type of system.

user: Individual, organization, or enterprise that uses, applies, or operates system products.

validation: *See end product validation and requirements validation*.

verification: *See end product verification*.

Appendix B – Enterprise-based Life Cycle (normative)

The various commercial and non-commercial enterprises, within widely diverse domains, have similar enterprise-based lifecycles, and generally exist for the same purpose. That purpose is to incrementally develop systems and control passage from one increment to another so as to reduce risk, control costs, and provide and maintain system products that will be competitive and provide user safe satisfaction throughout the life cycle.

Each enterprise-based life cycle is characterized by distinct phases marked by established exit criteria and management reviews to ensure that the exit criteria are satisfied prior to making a decision on whether or not to approve progress to the next phase or sequence of phases, or to make modifications or improvements to maintain competitiveness. Although the various enterprise-based life cycles may have different named phases, and different phase and life cycle time periods, most, if not all, have these five distinct functional phases: (1) assessment of opportunities, (2) investment decision, (3) system concept development, (4) subsystem design and pre-deployment, and (5) deployment/installation, operations, support, and disposal.

B.1 Relationship to engineering life-cycle phases

Figure B.1 shows five typical phases of an enterprise-based life cycle and the use of appropriate engineering life cycle activities to meet the exit criteria for the enterprise-based life-cycle phases.

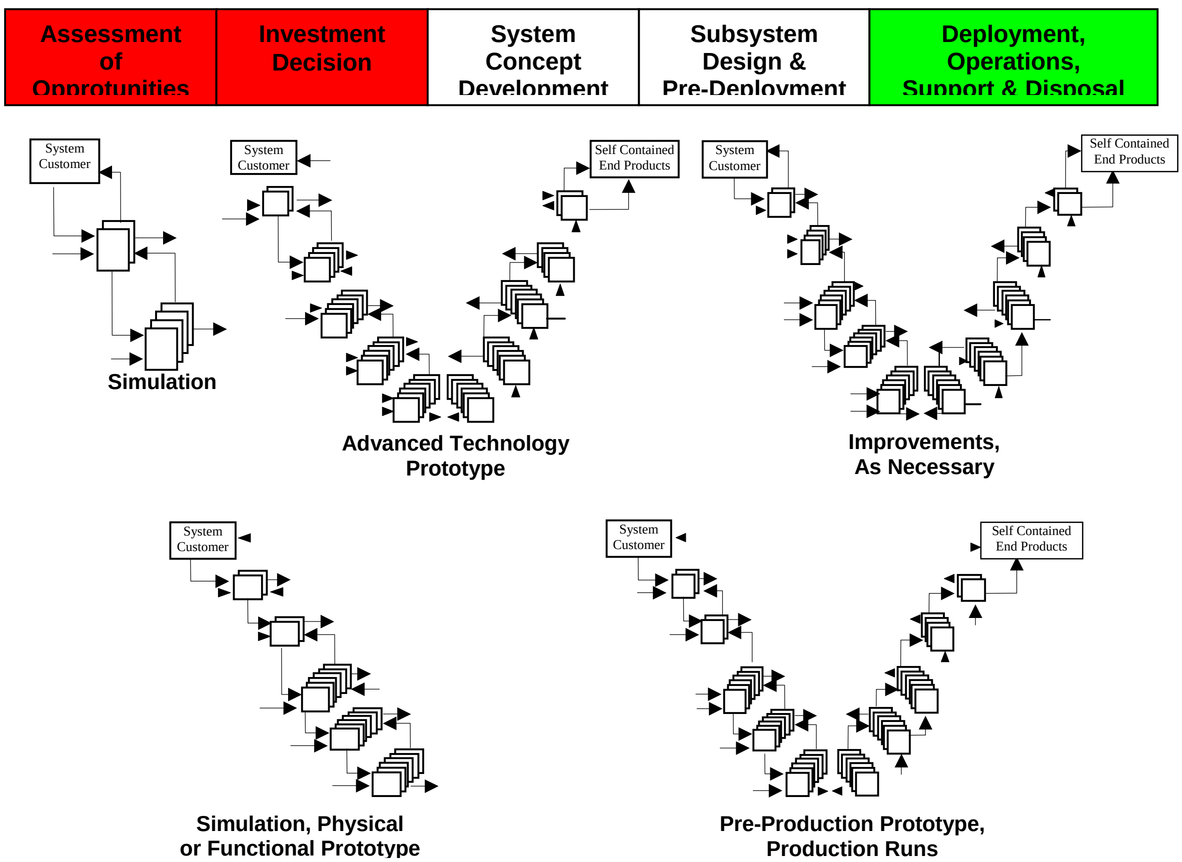


Figure B.1 – Enterprise-based life-cycle phases

NOTES

1 It is during the investment decision phase that a commercial or subsystem supplier organization typically prepares a proposal in response to a competitive solicitation, when such governs an enterprise's activities. In other organizations, such as government agencies, solicitation and proposal activities can occur before any of the above phases when competition is deemed appropriate.

2 Enterprise-based life cycles tend to be unique to an enterprise, and are subdivided by different phases that depend on the needs of the enterprise. These are generally based on the enterprise's own external environment. They are established, for example, in response to market cycles, government agency directives, or fiscal considerations. They are not generally based on engineering efforts required for a system development (or portions thereof), but on entry and exit criteria to meet internal or customer- driven milestones.

3 The key message of Figure B.1 is that appropriate engineering life cycle process activities are completed to meet the exit criteria of each enterprise-based life-cycle phase, regardless of the name or purpose of the phase.

B.2 Product evolution

During the early phases of this generic life cycle, various levels of system products are developed. For instance, during the first phase (assessment of opportunities), a simulation-produced prototype can be used to identify, qualify, and select new or improved system and business opportunities.

During the second phase (investment decision), a physical or functional prototype can be developed to understand a solution so that determination can be made whether to continue with the development and so that project plans are produced in preparation for transition to system development. For competitive developments, a bid or no bid can be determined and a proposal can be developed, if necessary.

During the third phase (system concept development), an advanced technology prototype can be developed, including one sufficiently operational to access performance and cost factors and to identify and reduce critical risk factors.

The forth phase (subsystem design and pre-deployment) produces a pre-production prototype, which will be used for verifications and validations and acceptance by the acquirer, and required production volume of end products and enabling products for deployment or installation.

The last phase (deployment/installation, operations, support, and disposal) is where the system products are deployed or installed for operation and various operational, maintenance, and disposal support provided, as required. During this last phase, reengineering is often necessary to keep the products competitive and useful. If needed, the processes of this Guide are applied while using the appropriate engineering life-cycle phases.

B.3 Life cycle considerations

Cost is an important criterion for both making a decision to develop a certain system and buying that system. Various heuristics attribute that from 60 to 80 percent of the life cycle cost of a system is experienced in the operations and support phase. It is essential, therefore, that focus be on ways to reduce such costs during the earlier phases of the enterprise-based life cycle. It is important to treat cost, especially pertaining to associated processes, as an independent variable while making trade-off analyses.

Appendix C – Process Task Outcomes (informative)

This Appendix provides an informative set of representative tasks and their expected outcomes for the thirty-three sub-processes of Section 4.

C.1 Acquisition and Supply task outcomes

Table C.1 – Sub-process 1 (Supply Process – Product Supply)

a) Representative tasks	**Expected outcomes**
a) Assess acquisition request, offer, or directive	The capability of the enterprise, organization, project, or team to provide a system, or portion thereof, that meets acquisition document requirements within the stated constraints and the enterprise strategic plan and business strategy, or within the project plan and constraints, or within the team charter, as applicable, is determined. Includes, as appropriate: 1) engineering and other applicable technical and project plans that allow determination of engineering and management tasks, costs, and schedules, resource requirements, and technical capabilities and capacities (invoke applicable Planning Process tasks); 2) decision whether to work with the acquirer to provide the desired system, or a portion thereof, based on establishment enterprise criteria or on project or team capability; 3) resolution of added or changed requirements and areas of concern; 4) preparation and submission of an appropriate technical and cost response in accordance with acquisition requirements, enterprise business strategy, and enterprise policies and procedures, or with project plans, policies, and directives.
b) Negotiate agreement	A satisfactory agreement is established based on the bounds determined by, as applicable: 1) applicable legal, regulatory, policies, procedures, and practices that will affect negotiation strategy or conduct; 2) the type of agreement to be negotiated; 3) negotiation strategy; 4) conditions identified from the plans for the procurement work effort that could affect negotiations and agreement performance; 5) constraints identified from the plans for the procurement work effort that could affect negotiations and agreement performance.
c) Record agreement	Established agreement is captured in a form and medium appropriate to the effort.
d) Implement agreement	A project established and processes (including replanning, as necessary) activated to complete the requirements of the agreement.
e) Deliver product and other deliverables per agreement	Agreement requirements satisfied by the delivery of required products and other deliverables in accordance with agreement instructions.

Table C.2 – Sub-process 2 (Acquisition Process – Product Acquisition)

Representative tasks	Expected outcomes
a) Prepare acquisition requests, offers, or directives	Acquisition documents, as applicable to the technical effort, prepared to include: 1) plans to be provided to suppliers, as applicable; 2) purpose of the acquisition, the essential requirements to be met, the products to be delivered by a supplier, and the operational concept and expected operational environment for each product, as applicable; 3) what the products to be delivered must be able to do; how well the products must perform; desired characteristics of the products, constraints, and other essential product attributes; management concerns including line of authority, financial management, and reporting; and requirements that can affect the cost, schedule, and risk in accomplishing the work effort or delivery of the product; 4) concerns such as cost and schedule that can constrain the work effort or product, and states whether or not the concern can be traded off; 5) expected tasks or work to be done by the supplier; 6) the data and other work products to be delivered, including form, format, and schedule.
b) Evaluate supplier response	Supplier or suppliers selected that will do the agreed-to work and provide the desired products, as appropriate.
c) Make offer or provide directive	Offer made or directive provided to the selected supplier or suppliers.
d) Negotiate agreement	A satisfactory agreement established based on the bounds determined by, as appropriate: 1) applicable legal, regulatory, policies, procedures, and practices that will affect negotiation strategy or conduct; 2) the type of agreement to be negotiated; 3) negotiation strategy; 4) conditions identified from the plans for the procurement work effort that could affect negotiations and agreement performance; 5) constraints identified from the plans for the procurement work effort that could affect negotiations and agreement performance.
e) Record agreement	Established agreement is captured in a form and medium appropriate to the effort.
f) Accept delivered products	Installed or delivered system products validated as satisfying the user, customer, or assigned requirements, and other applicable certification or acceptance criteria.

Table C.3 – Sub-process 3 (Acquisition Process – Supplier Performance)

Representative tasks	Expected outcomes
a) Define supplier relationships	The type of supplier support required, level of participation, procedures and criteria for selection and control, procedures for participation, as appropriate, on developer's multidisciplinary teams, and an appropriate acquirer-supplier agreement are established.
b) Participate on product teams	Agreed-to procedures for participation of supplier personnel on developer multidisciplinary product teams and for participation of developer personnel on

	supplier multidisciplinary product teams are implemented.
c) Monitor product metric data	Supplier performance against product metrics established in the agreement is determined. Invoked the applicable tasks in the Assessment Process.
d) Flow-down changes in requirements of operational concept	Assurance made that all requirement and operational concept changes affecting the supplier's project have been properly communicated to the supplier.
e) Control requirement changes	All changes approved to functional and performance requirements and to constraints, made by the supplier, that would affect the developer's project or other related projects or products. Approved changes have been appropriately distributed and implemented.
f) Assess progress against requirements	Progress against assigned requirements included in the agreement and as changed by established change procedures is determined. Required technical reviews completed. Invoked applicable tasks of the Assessment Process.
g) Validate products received	Assurance made that delivered products satisfy assigned requirements and approved changes. Resolution of identified variations resulting from validation of the delivered product is complete. Invoked the applicable tasks of the End Products Validation Process.

Table C.4 – Sub-process 4 (Planning Process – Process Implementation Strategy)

Representative tasks	Expected outcomes
a) Identify stakeholders	Intended users or customers and other stakeholders who will have an interest or stake in the outcome of the project are established.
b) Identify applicable documents	Applicable source and technical documents and the requirements therein that could affect the project effort are identified and acquired, including: 1) the scope and purpose of both the project and products to be developed or reengineered; 2) stated purpose of the products, expectations of the stakeholders, expected benefits to stakeholders, as well as the goals and objectives of the system, or portion thereof, to be developed or reengineered; 3) enterprise policies, priorities, and constraints on funding, personnel, facilities, manufacturing capability and capacity, and critical resources that will affect accomplishing the requirements and goals of the source and technical documents; and 4) (a) applicable processes, standards, and specifications; (b) core enterprise technologies; (c) risks to business growth by new project; (d) must-win criteria; (e) net cost targets; (f) methods of resource allocation; (g) how work and changes will be authorized; (h) how information will be captured; (i) how work packages will be formed and controlled (j) scope and procedures for trade-off analyses, effectiveness analyses, and risk management based on enterprise goals and planning baselines.
c) Identify associated process approaches	How development of enabling products associated with production, test, deployment/installation, and logistics processes will be implemented is determined.
d) Identify applicable life-cycle phases	Applicable enterprise-based life-cycle phases (see Appendix B.2), the expected work product outputs and management reviews, and the relevant exit criteria for each applicable enterprise-based life-cycle phase, including level of product maturity expected, level of acceptable risk, management review concerns, and documentation requirements, are determined.

e) Identify and define technical process and project integration	How the applicable processes of this Guide will be integrated with each other and with other processes specified in enterprise and agreement documents, and which internal and external projects that will be involved and how they will be integrated are determined.
f) Identify and define progress against assessment	Required reporting requirements, specific product and process metrics to be used, how and when metrics will be collected and by whom, and how progress will be assessed are determined.
g) Prepare the process implementation strategy	A process implementation strategy document based on the integrated results of the outcomes of the above tasks is prepared.

Table C.5 – Sub-process 5 (Planning Process – Technical Effort Definition)

Representative tasks	Expected outcomes
b) Identify project requirements	The following are determined: 1) Specific requirements include (a) work that the supplier is required to accomplish, (b) functions of the system, or portion thereof, to be furnished, engineered, or improved; how well the functions are to be performed; any required physical characteristics; and the operations concept, (c) data to be delivered and when, (d) budget and schedule requirements, and (e) other technical requirements provided in acquirer-supplied planning documents; 2) Other stakeholders who have or who will have requirements or expectations with respect to the work to be accomplished or the system to be provided (for example, local, national, or international government agencies; persons living or working in the areas near where system products will be used or where products will be developed and produced; commercial or military competitors; and employees involved with the project); 3) Potential conflicts between the acquirer-supplier agreement (proposed or final), the process implementation strategy, and enterprise policies and procedures, core technologies, and capacities; 4) Specific constraints and any conflict between the process implementation strategy and the agreement (proposed or final) with respect to development, production, test, deployment, support, or disposal of the system products to be delivered, or the training of personnel required to operate and maintain the products.
c) Establish information database	The types and quantity of data and schema and other information that will have to be recorded and maintained, as well as access and security requirements, are determined; a database that can securely retain and make available project information, as required, is established.
d) Define risk management strategy	The following are determined: (1) how the technical risk areas of the technical effort will be identified and tracked; and (2) the appropriate risk aversion approaches based on the acceptable levels of risk specified in the agreement or in enterprise policies and procedures.
e) Define product and process metrics	The following are defined; (1) product metrics by which the quality of the product is to be evaluated; (2) process metrics by which the efficiency and effectiveness of the tasks of the technical effort are to be evaluated; and (3) frequency and methods by which product and process metrics are to be collected.
f) Establish cost	Rigorous cost goals (ownership, acquisition, operating, support, and disposal) to be

objectives	used in trade-off analyses are established.
g) Identify technical performance measures	The following are determined: (1) technical objectives related to success of the system, or portion thereof, [e.g., measures of effectiveness (MOEs) by which the user, customer, or acquirer will measure satisfaction or acceptance]; and (2) key performance parameters that will receive management focus and are to be tracked using Technical Performance Measurement (TPM) procedures.
h) Identify applicable tasks	The following are identified: (1) key events of the project (e.g., technical reviews, physical integration, major test, product and process verifications, and end product validation) established by input planning documents; (2) entry and exit completion criteria for each event; and (3) tasks required for meeting the entry and exit criteria of each event and for accomplishing each applicable process. NOTE – The following structure of tasks can be helpful for accomplishing scheduling staffing determination, and resources required: 1 Key events required to meet technical requirements (e.g., test and technical review). 2 Primary tasks related to accomplishing entry and exit criteria of each key event (e.g., define stakeholder requirements and prepare engineering drawings). 3 Support tasks that enable the staff accomplishing primary tasks to meet their objectives (e.g., provide resources, equipment, facilities, acquire appropriately skilled personnel for accomplishing primary tasks, and arrange travel). 4 Management tasks required to direct, monitor, review, and approve the primary and support tasks (e.g., serve as chair of a technical review, and review and approve documents for transmittal to the customer).
i) Identify methods and tools	The following are determined: (1) appropriate methods for accomplishing identified tasks, or groups of tasks of each applicable process; (2) required automated tools; (3) required specialized facilities and equipment; and (4) training requirements.
j) Establish technology insertion approaches	The applicable or potential technology constraints are identified and the approach for conducting parallel technology developments, and planned technology insertions are established.

Table C.6 – Sub-process 6 (Planning Process – Schedule and Organization)

Representative tasks	Expected outcomes
a) Develop event-based schedule	The key events for the technical effort associated with applicable enterprise-based life-cycle phases, related applicable tasks to each event, and the completion criteria for each task and an event are developed and documented.
b) Develop calendar-based schedule	The calendar date that each key event will be completed or expected to be completed; the planned start and completion time for accomplishment of each task (primary, support and management); and the dependency relationships between tasks, between tasks and events, and between events and other events are developed and documented.
c) Identify resource requirements	The material resources, facilities, and equipment required to complete each scheduled primary, support, and management tasks are determined, and the date such resources are required is specified.
d) Define staffing needs and discipline	The following are determined: (1) personnel needs by discipline and performance level to complete scheduled primary, support, and management tasks, and the date

needs	each staffing need is required; (2) internal and external supplier training needs and schedules to achieve required proficiencies; and (3) risk to the project, if adequate staffing is not available.
e) Define team and organizational structure	(1) The multidisciplinary teams needed to carry out the planned technical efforts and produce required work products are formed within enterprise and project resource constraints; (2) The composition of teams by functional and disciplinary membership that are organized to support specific system product development is established; (3) The names of staff members assigned to each team are established; (4) Responsibilities and authority of teams and team members are defined; and (5) Roles, responsibilities, authority and boundaries for each team are established.

Table C.7 – Sub-process 7 (Planning Process – Technical Plans)

Representative tasks	Expected outcomes
a) Develop Engineering Plan	An efficient and economical means of implementing the processes for engineering a system is defined and documented. It answers the following questions: 1) What is the general problem to be solved? 2) What is the benefit to the acquirer (enterprise perspective)? 3) What is the application context of the general problem to be solved? 4) What is the boundary of the general problem to be solved, denoting what can be controlled by the developer (inside) and what influences the development and is influenced by the development but not controlled by the developer (outside)? 5) What are the required inputs and outputs? 6) What are the influencing factors and constraints? 7) How are the system concerns, as appropriate, of reliability, availability, maintainability, security, safety, health factors, survivability, electro-magnetic compatibility, radio frequency management, and human factors being considered and included? 8) What processes and tasks must be accomplished? 9) How will each process be accomplished? 10) What resources, methods, and tools are necessary to accomplish the tasks of each process? 11) How will the required resources and tools be acquired? 12) What is the organizing structure? 13) How will the organization be staffed and managed? 14) What are key intermediate events leading to project completion, and how will their occurrence be determined? 15) When, where, and by whom will tasks and events be completed? 16) What are the risks involved? How will risks be managed? 17) What are the completion criteria for the process tasks? 18) What are the entry and exit criteria for reaccomplishing each process? 19) How will project completion be determined? NOTES 1 The engineering plan usually covers one or more phases of the enterprise-based life cycle and the applicable phases of the engineering life cycle. 2 The engineering plan is to cover process applications within the engineering life cycle to meet the exit criteria of the applicable enterprise-based life-cycle phases, as consistent with the acquirer-supplier agreement and the extent of the project conducted within an enterprise.
b) Develop Risk Management Plan	Documentation of the tasks to be accomplished by project teams and analysis for identification of potential risks, characterization and prioritization of identified risks, aversion of risks, and tracking and control of risks, and communication of risk status

	are defined and documented.
c) Develop Technical Review Plan	Tasks to be accomplished to implement required technical reviews and a detailed description for each review are developed and documented to include: (1) a check list for tasks to be accomplished, (2) entrance and exit criteria, (3) review schedule, (4) documentation requirements, (5) distribution list for technical data package, (6) participants, and (7) responsibilities of participants.
d) Develop Validation Plans	The tasks to be accomplished and the resources to be allocated and scheduled for validating that: (1) the system technical requirements, logical representations, and derived technical requirements are well formulated (see Sub-process 25) and conform to their respective sources, and (2) the products received from suppliers, or delivered to an acquirer, conform to the user, customer, or assigned requirements associated with the end product are defined and documented.
e) Develop Verification Plans	The tasks to be accomplished and the resources to be allocated and scheduled for verifying that: (1) the selected and characterized physical solution description satisfies the assigned system technical requirements, logical representations, and derived technical requirements (2) end products satisfy their specified requirements, and (3) enabling products will be ready when required to provide life cycle support to their respective end products are defined and documented.
f) Develop Other Applicable Plans	The tasks to be accomplished to complete required control activities or other design activities such as design-to-cost, Technical Performance Measurement, technology insertion, safety, security, human factors engineering, and maintenance reliability (see Appendix D for others), as required in an agreement or by enterprise policies and procedures, are defined and documented.

Table C.8 – Sub-process 8 (Planning Process – Work Directives)

Representative tasks	Expected outcomes
a) Develop work packages	The work required, input sources, schedules, budget, and reporting requirements to implement, execute, and control the work are defined and documented.
b) Generate work authorizations	Approval/disapproval of work packages is assigned, and work authorizations are documented.

Table C.9 – Sub-process 9 (Assessment Process – Process Against Plans and Schedules)

Representative tasks	Expected outcomes
a) Identify events, tasks, and process metrics for monitoring	The events and tasks that must be monitored, as well as the metrics that will be used to assess progress against plans and schedules, are identified. The applicable expected values for each progress metric are established.
b) Collect and analyze process metric data	Results from completion of required tasks and events, and process metrics data are determined and tracked.
c) Compare process metrics data against plans and schedules	The following are determined: (1) completion of required tasks and events, (2) variances of metrics from expected values, (3) progress variances from plans and schedules, (4) technical areas requiring management or team attention, and (5) cost and schedule risk.
d) Implement required changes	The cost effective changes to correct variances and needed changes to plans and schedules, and required changes, revised work directives, and updated plans to reflect approved changes and management decisions are identified, approved, and implemented.

Table C.10 – Sub-process 10 (Assessment Process – Progress Against Requirements)

Representative tasks	Expected outcomes
a) Identify product metrics to be monitored	Product-related metrics, and their expected values, that will affect the quality of the product and provide information of the progress toward satisfying user/assigned requirements, other stakeholder requirements, and derived requirements are identified and documented.
b) Collect and analyze product and metrics data	The following are determined, as appropriate: (1) analyzed, estimated, or measured values of key performance parameters at predetermined events (e.g., simulation and prototype tests), (2) compliance to applicable requirements, (3) levels of technical risks, (4) marginal cost benefit of performance beyond requirements, (5) degree of customer satisfaction and public acceptance, and (6) effect of a key performance parameter status on related end-user products.
c) Record rationale for decisions and assumptions made	The following are determined, as applicable: (1) satisfaction of alternatives based on recommendations and effects of trade-off and effectiveness analyses and (2) assumptions associated with decisions made during requirements definition, solution definition, trade-off analyses, effectiveness analyses, verifications, and validations.
d) Compare results against requirements	The following are determined, as applicable: (1) satisfaction of technical requirements, (2) progressive maturity of the system, or portion thereof, being engineered/reengineered, (3) variances from expected values from Technical Performance Measurements, and (4) variations from requirements resulting from end product verifications and end product validations.
e) Identification and Implementation of Required Changes	The following are identified, evaluated, and implemented, as applicable: (1) alternative corrective actions to mitigate out-of-tolerance Technical Performance Measurements, (2) other changes to be implemented so that products will meet requirements, (3) recommended user/assigned, other stakeholder, or technical requirement changes, and (4) implementation of revised specifications and configuration baselines that reflect approved changes and management decisions.

Table C.11 – Sub-process 11 (Assessment Process – Technical Review)

Representative tasks	Expected outcomes
a) Identify technical review objectives and requirements	The following are identified and documented: (1) purpose and objectives of the review, (2) agenda requirements, (3) tasks to be completed at each required review, (4) entrance and exit requirements, (5) documentation requirements, (6) distribution requirements, and (7) responsibilities of the review participants.
b) Determine progress against event-based plan	The satisfaction of entrance requirements to the review are determined and documented.
c) Establish technical review board, agenda and speakers	For each review, the following are established: (1) persons who will participate in the review, (2) chairpersons, (3) secretary, (4) reviewers of the presentation, (5) agenda that meets review requirements and ensures that all required tasks are completed, and (6) members of the design team that will prepare the data package, and prepare the presentation, prepare material for distribution at the review, make presentations, answer questions, and accomplish task close out action items.
d) Prepare technical review package and presentation materials	Comprehensive read-ahead material is prepared that includes sufficient information so that technical board members can understand the design and participate effectively in the review. Review team responsibilities, agendas, plans, and expectations from the review are defined and documented. A comprehensive set of presentation materials that describe the assigned design topics and that satisfy review objectives is

	prepared.
e) Facilitate resolution of emerging issues	Emerging issues identified and resolved prior to the review.
f) Conduct technical review	The following are assessed by the review: (1) maturity of system, or portion thereof, being engineered, (2) progress according to plans and requirements, (3) risks and variances in cost schedule, and performance, and (4) readiness to proceed with the next phase of development. Action items required to meet review objectives are generated, recorded and assigned.
g) Close-out review	The following are completed for review close-out: (1) preparation and distribution of minutes that include purpose, time, place, attendees, decisions, action items, due date, and persons responsible for resolving action items, (2) resolution of action items, and (3) sign off by chairperson.

Table C.12 – Sub-process 12 (Control Process – Outcomes Management)

Representative tasks	Expected outcomes
a) Capture process outcomes	The following are recorded in the information database: (1) the outputs of the technical processes implemented in the engineering of a system, (2) the methods, tools, models, and metrics used, (3) recommendations, decisions, assumptions, and effects, (4) lessons learned, and (5) other data that allows traceability of requirements.
b) Perform configuration management	The configuration of the products is documented and made available. The following is realized: (1) product configuration is known and reflected in product information, (2) beneficial product changes are effected without adverse consequences, (3) change is managed from the first implemented phase during system design, (4) information that will be needed to make later decisions on products is captured, (5) consistency between a product and information about the product, and (6) capability to distinguish between product versions or builds. NOTE – ANSI/EIS-649 can be used in conjunction with this Guide, for configuration management.
c) Perform change management	Traceability of change is maintained and controlled, including source of the change, processing methods, approvals, and implementations in accordance with the Change Management Plan.
d) Perform interface management	System internal and external interfaces are maintained and controlled, including completion of interface definition, assessments of compatibility, changes, and coordinations and approvals in accordance with the Interface Management Plan. Interfaces are managed, ensuring that: (1) all internal and external functional and physical (including human) interfaces for a building block are identified, defined, assigned, documented, and managed, (2) building block design definitions are compatible in terms of form, fit, and function, and (3) interface changes affecting the building block and affected by the building block (see Section 6) are controlled to prevent adverse consequences.
e) Perform risk management	Potential risks are identified, characterized and prioritized, and properly averted, tracked and controlled. Risk status is communicated in progress reports, in proposals, and at technical reviews, in accordance with the Risk Management Plan. A clear view of future risks is provided, better decision making is enabled, and problems are prevented from occurring – but if they do occur, a plan exists to mitigate the effect of the problem. NOTES 1 Risk is always present in an engineering or reengineering project. Sources of risk include the tendency of acquirers to: (1) desire products of a system that

	are intended for technical accomplishment near the limits of the state of the art (performance), (2) push for delivery of system products as soon as possible to meet an imminent market opportunity or threat, and (3) limit funding available. Additionally, risks come from both internally and externally imposed constraints (e.g., resource, capacities, environmental conditions, and reuse). 2 The major sources of risk are programmatic, schedule, political, financial and technical. Risks are greater when planning, control, resources and time are inadequate. Risks are also greater when information is not available for decision-making, or when the information is too much, too little, irrelevant, or inaccurate.
f) Perform data and document management	Data and documents are maintained and controlled, including development support, handling and storage, and required technical data and document delivery in accordance with the Data Management Plan. Data and document management includes capturing data and documents generated during implementation of the processes of this Guide, and generating and maintaining an evolving technical data package. A typical data package includes: (1) a buy-to description (e.g., detail specifications and/or final drawings), (2) a build-to description, (3) design documentation, (4) engineering changes, deviations, and waivers, and (5) enabling product descriptions. Build-to descriptions include: (1) models, drawings, and specifications, (2) production planning, (3) tool design, (4) bill of materials, and (5) statistical process control plan. NOTE – Multidisciplinary teamwork is essential to ensure the accuracy and completeness of technical manuals and the technical data package.
g) Manage information database	Relevant data and information are maintained and controlled for the project, including inputs and outputs of control process tasks and ensuring back-ups, if applicable, of digital databases. Relevant data includes: 1. Inputs and outputs of technical process activities: a) work products (e.g., specifications, drawings, and code lists); b) archival data (e.g., decisions made [including rationale], assumptions, lessons learned, changes, and empirical data); c) stakeholder requirements (e.g., technical objectives, constraints, and interfaces); d) requirement, functional, and physical architectures; e) physical models developed (e.g., prototypes, breadboards, brassboards, and mock ups); f) simulation model outputs and assumptions; g) metrics (e.g., cost and technical performance measures); h) planning documents (e.g., engineering plan and technical event plan); i) technologies. 2. Process models used for: a) analysis of problem (analysis of requirements and analysis of functions) (e.g., Quality Function Deployment, behavior, and time); b) solution definition (synthesis) (e.g., for design); c) validation and verification; d) system analysis (e.g., for trade-off analyses, risk analyses, and effectiveness analyses); e) control (e.g., interfaces, data, configurations, schedules, costs, product performance, reviews, and assessments). 3. Tools used: a) automated tools (e.g., traceability, analysis, and design); b) validation and verification tools; c) trade-off analysis support tools; d) communication tools; and

	e) status reporting/projection tools.
h) Manage and track requirements	The following are maintained and controlled: (1) input requirements (acquirer and other stakeholder), system technical requirements, logical solution representations, physical solution representations, derived technical requirements, and specified requirements, (2) validation results, (3) requirement changes resulting from resolution of variances, and (4) changes made to requirements through formal change procedures from Configuration Management, Change Management, and Interface Management tasks.

Table C.13 – Sub-process 13 (Control Process – Information Dissemination)

Representative tasks	Expected outcomes
a) Provide progress status	Process and product metric data have been disseminated according to the agreement, engineering plan, and enterprise policies and procedures, and to meet approved requests.
b) Provide planning information	Work packages and appropriate technical plans have been disseminated to project teams and other required or approved recipients.
c) Disseminate approved and controlled requirements	Acquirer/assigned, other stakeholder, system technical and derived technical requirements, and all changes to requirements are distributed in a timely manner to all stakeholders to ensure that all work is conducted in accordance with the latest approved requirements.
d) Provide information for and from reviews	The following have been disseminated, as appropriate: (1) read-ahead technical review package to technical review board members, (2) information and items necessary to demonstrate that event-based criteria have been satisfied for initiation of the review, (3) information packages and presentation materials at the review, (4) minutes of the review action items required for closure, and final close-out approval.
e) Make available design data and schema	Data pertinent for the technical effort have been disseminated to project teams and team members to ensure information availability for decisions and events, and to other authorized recipients requesting information.
f) Make available lessons learned	Lessons learned have been disseminated to other projects within the enterprise and to other teams within the project.
g) Report variances	Product and process variances have been reported along with (1) recommended actions to return the product or process metric to established expectations or requirements, (20 cost and schedule impacts, and (3) effects on the project if no action is taken.
h) Disseminate data deliverables	Data deliverables have been disseminated as required by the agreement, enterprise policies and procedures, the engineering plan, and other technical plans.
i) Disseminate approved changes	Approved requirements and design changes and updated plans have been distributed to approved or required recipients.
j) Disseminate directives	Work directives resulting from management decisions have been disseminated to intended recipients that initiate or change work by project teams or support organizations within the enterprise.

Table C.14 – Sub-process 14 (Requirements Definition Process – Acquirer Requirements)

Representative tasks	Expected outcomes
a) Identify, collect, and prioritize acquirer's system requirements	User, customer, or assigned requirements for a system, or portion thereof, have been identified and defined in terms of needs, expectations, capabilities, and priorities, or of assigned requirements for a system, or portion thereof, as expressed in specifications. Specifically, the following have been identified, as applicable: 1) concept of operation; 2) what the acquirer wants the products of the system to accomplish (functional requirements); 3) how well each function must be accomplished (performance requirements); 4) natural and induced environments in which the system must operate or be used; 5) design constrains such as use of non-developmental or reusable items; 6) requirements pertaining to the availability, electro-magnetic compatibility, health factors, human factors, interoperability, maintainability, reliability, safety and security; 7) measures of effectiveness (MOEs) that reflect overall expectations against which satisfaction will be determined; and 8) constraints pertaining to development, production, test, deployment/installation, training, support/maintenance, and disposal.
b) Ensure completeness and consistency of the set of collected acquirer requirements	The collected user, customer, or assigned requirements are validated. Resolution of all conflicts and variances is completed. Invoked the Requirements Validation Process, Sub-process 26.
c) Record the set of acquirer requirements	Validated set of acquirer requirements is captured in the established information database.

Table C.15 – Sub-process 15 (Requirements Definition Process – Other Stakeholder Requirements)

Representative tasks	Expected outcomes
a) Identify and collect other stakeholders' end product requirements	Other types of requirements that can constrain the engineering of the system's end products are identified, collected, and defined, such as: 1) project plans; 2) team assignments and organization; 3) automated tools availability and approval for use; 4) required metrics; 5) decisions from management or technical reviews; 6) enterprise standards, guides, policies, and procedures; 7) enterprise technologies; and 8) enterprise physical and financial resources.
b) Identify and collect other stakeholders' enabling product requirements	Enabling product requirements associated with manufacturing/production, test, deployment/installation, training, support, and disposal (including disposal) processes including enterprise capacities (facilities, equipment, tools, and staff) to accomplish these processes are identified, collected, and defined.

c) Identify and collect other stakeholders' external constraints	Other end product and development process constraints from external sources are identified, collected, and defined, such as; 1) national and international standards, laws, and regulations (including environmental protection, hazardous material exclusion list, and waste disposal); 2) technology base; 3) industry and international standards and general specifications; 4) competitor product capabilities and trends; and 5) interfaces with other existing or evolving systems and platforms.
d) Ensure completeness and consistency of the set of other stakeholders' requirements	The collected set of other stakeholder requirements is validated. Resolution of all conflicts and variances is completed. Invoked the Requirements Validation Process Sub-process 27.
e) Record the set of other stakeholder requirements	Validated set of other stakeholder requirements is captured in the established information database.

Table C.16 – Sub-process 16 (Requirements Definition Process – System Technical Requirements)

Representative tasks	Expected outcomes
a) Establish required transformation rules, priorities, inputs, outputs, states, modes, and configurations	Transformation rules, priorities, inputs, outputs, states, modes, and configurations that will influence and affect the other tasks for definition of system technical requirements are identified and defined, as appropriate to each system product.
b) Define operational requirements	The range of anticipated use of the end products, as identified in the concept of operations or specification, or for potential end products, is defined, including for each operational profile, the definition of: 1) the utilization environment and factors, natural or induced, that can affect end product performance; 2) the events to which end products must respond; 3) the physical and functional interfaces (e.g., mechanical, electrical, thermal, data, and procedural) including physical interactions (e.g., form and fit), system boundaries (what is controlled by the developer) and interactions (e.g., information flows and behaviors) of products or environments within developer control and those systems or environments outside system boundaries; 4) what system end products must be able to accomplish (functional requirements) to satisfy acquirer identified requirements. Includes factors such as producibility, testability, transportability, installability, operability, supportability, disposability, reliability, availability, maintainability, security, and safety; and 5) how often end products will be used, cycle time between use, and how often each product function will be accomplished.

c) Define performance requirements	The following are defined; (1) the performance expectations for each functional requirement (how well the function must be accomplished), (2) the set of measure of performance (MOPs), made up of the functional and performance requirements combinations, associated with each MOE, (3) the key performance parameters (KPPs) selected from the MOPs that will be key indicators of end product or system performance, and if not met, that will cause the associated MOE to not be satisfied and will put the project in cost, schedule, or performance risk, and (4) functional and performance testability approach for each requirement statement.
d) Analyze acquirer and other stakeholder requirements to: 1) Define human factors effects 2) Establish capacities and timing 3) Define technology constraints 4) Define product design constraints 5) Define enabling product requirements 6) Identify conflicts 7) Determine Trade-off analysis criteria	The following are identified and defined, as applicable: 1) the user or operator roles, as applicable, and the human factor effects (ergonomic limitations, work space, eye movement, access, cultural background, natural and induced environmental constraints, work tasks, and time constraints) associated with functional performance requirements on potential users, operators, installers, or recipients and handlers of the system end products 2) required capacities (e.g., memory, storage, and flows) of end products and timing of events, states, modes, and functions related to each operational profile 3) any constraints or limitations from use of existing technologies and the risks associated with using any unproven technologies 4) any constraints that will influence or affect end product design (e.g., materials, special skills, and automated tools), required physical characteristics (e.g., size, color, texture, weight, and buoyancy), operator safety, system security, reuse requirements, standardization of end products, open system architecture, maintainer access, handling and storage, transportability, and other attributes of end products or design processes for which trade-offs cannot be made 5) technical requirements for enabling products associated with processes to develop, produce, test, deploy/install, operate, support/maintain, train, and retire/dispose of end products under development or being improved 6) conflicts among the requirements set 7) the set of risk, cost, schedule, and performance criteria to be used in conducting trade-off analyses for conflict resolution. NOTES 1 Developers are to ensure that residual risks from constraints are not significant to harm or otherwise prevent the system from performing its functions, create unacceptable costs, or price the system's end products out of competitiveness. 2 Analyses of system requirements can necessitate consideration of existing or possible physical solutions to ensure feasibility.
e) Challenge questionable requirements	Acquirer and other stakeholder requirements that are of questionable utility or that have an unacceptable risk of satisfaction are identified and resolved.
f) Resolve identified conflict of requirements	Any conflicts between combinations of functional requirements, performance requirements, or constraints, as well as within respective sets of those requirements, are resolved. Invoked the System Analysis Process, Sub-process 23.
g) Prepare a set of acceptable system technical requirements	Associated assumptions and technical requirement statements for the system are prepared and then validated. Invoked the Requirements Validation Process Sub-process 25.

h) Ensure completeness and consistency of the set of system technical requirements	System technical requirements are validated. Resolution of variances is completed. Invoked the Requirements Validation Process, Sub-process 28.
i) Record the set of system technical requirements	The validation set of system technical requirements and associated assumptions is captured in the project's information database and maintained and controlled throughout the life of the project. NOTE – Controlled maintenance of the system technical requirements in the information database allows for traceability, supports validation, and is essential for change management.

Table C.17 – Sub-process 17 (Solution Definition Process – Logical Solution Representations)

Representative tasks	Expected outcomes
a) Select and implement one or more of the four approaches below, or the approach designated by enterprise policies, guides, or standards: 1) Functional analysis 2) Object-oriented analysis 3) Structured analysis 4) Information modeling 5) Other techniques	An abstract definition of the solution is provided in the form of: 1) functional flow, timelines, behaviors, data and control flows, states and modes, functional failure modes and effects. 2) objects encapsulating a partition and mapping of System Technical Requirements and characterized by services (behaviors, functions and operations) provided and by encapsulated attributes (values, characteristics, and data) 3) model data and functions with algorithms derived from contextual diagrams and data flow diagrams used to decompose functions while explicitly showing the data needed for each function 4) data structures with their functions and processing flows related to the data and associated with assigned system technical requirements 5) outcomes from other techniques (dependent on the nature of that particular methodology)
b) Establish sets of logical solution representations by: 1) Performing Trade-off analyses 2) Identifying and defining interfaces 3) Analyzing behaviors 4) Identifying and defining states and modes 5) Identifying and defining timelines 6) Identifying and defining data and control flows	NOTE – There is no set format or form for the various definitions of logical solutions. The format or form selected is that which best defines the functional, behavior, or data flow or data structure, as appropriate, and that will allow best assignment to potential end products, manual operations, or enabling products for generating physical solution representations. One or more sets of logical solution representations that are appropriate to the engineering life-cycle phase and the system being engineered or reengineered have been formed and defined, and include: 1) Acceptable logical arrangements and sequencing, or derivative representations (e.g., subfunctions, timelines, objects, data structures, and threads) defined by invoking the System Analysis Process, Sub-process 23. 2) Interfaces related to logical arrangements and sequencing, or derivative representations, to include, for example, start and end of states and inputs and outputs defined. Interface attributes identified and defined that trigger, for example, a behavioral response, change of state or mode, or data flow. 3) The responses (outputs) of the subfunction, group of subfunctions, objects, etc., to stimuli (inputs) for each operational profile identified and defined, as appropriate. Executable threads identified and defined, as appropriate, through

7) Analyzing failure modes and defining failure effects	the logical arrangements and sequencing, or derivative representations. 4) The states and modes for which subfunctions, groups of subfunctions, groups, objects, etc., exhibit different behaviors are identified and defined. 5) Timelines associated with a sequence of functions, objects, etc., for each operational profile are defined, as appropriate. Ranges for execution time and conditions that cause normal and abnormal performance are identified and defined. 6) The following are defined, as appropriate, (1) data flows among subfunctions, groups of subfunctions, objects, etc., for each operational profile, and (2) execution controls of each subfunction, and among groups of subfunctions or objects, for each operational profile 7) The functional or behavioral consequences of any specific functional failure that represent significant safety, security, human factor, performance, or environmental hazards are determined and prioritized. Alternative actions to resolve high-priority failure consequences are determined.
c) Assign system technical requirements (including performance requirements and constraints	System technical requirements (including performance requirements of a functional requirement and constraints) assigned to appropriate subfunctions, groups of subfunctions, objects, data structures, etc. NOTE – There can be unassigned system technical requirements after the tasks of Sub-process 17 are completed (see the note in Sub-process 17 task c).
d) Identify, define, and validate derived technical requirement statements	Derived technical requirement statements prepared that: (1) reflect requirement associated with defined logical solution representations from tasks a) and b), (2) constitute expansion of previously defined derived technical requirements into more detailed lower level requirements, (3) represent system technical requirement statements (such as range) that are not appropriate for logical solution representations but through analysis can be made more specific (such as fuel capacity, engine efficiency, and vehicle resistance), and (4) individually and as a set, are well formulated in accordance with Sub-process 25.
e) Ensure completeness and consistency of logical solution representations	Logical solution representations and assumptions are validated. Resolution of identified variances is completed. Invoked the Validation Process Sub-process 29.
f) Record logical solution representations and derived technical requirements	The following are captured in the information database: (1) the data generated, selected arrangements and sequencing, assignments of system performance requirements, and constraints, (2) the validated sets of logical solution representations, (3) the derived technical requirements, along with source rationale and assumptions, and (4) any unassigned system technical requirements see the note in Sub-process 17 task c).

Table C.18 – Sub-process 18 (Solution Definition Process – Physical Solution Representations)

Representative tasks	Expected outcomes
a) Analyze logical solution representation sets, assigned system and derived technical requirements	The following are determined: 1) which logical solution set or assigned requirement provides a requirement for an enabling product associated with development, production, test, deployment/installation, training, support/maintenance, or disposal; 2) which logical solution set or assigned requirement can best be accomplished manually or by facilities, material, or data; and 3) which logical solution set or assigned requirement can best be accomplished by hardware, software, or firmware products (new or existing). Invoke the System Analysis Process, Sub-process 22 and 23, as necessary.
b) Assign representations, derived technical requirements and unassigned system technical requirements to appropriate physical entities	The appropriate sets of functions, groups of functions, objects, behaviors, derived technical requirements, etc., are assigned to appropriate physical entities (e.g., sensor, engine, power source, storage device, structural frame, communication device, and computer) that will make up a physical solution. NOTE – This assignment to physical entities and generation of alternative solutions composed of these entities is tightly coupled and iterative.
c) Generate and evaluate alternative physical solution representations by performing the following tasks: NOTE – Appropriate models (digital, hardware or software, or both, partial or complete) or prototypes are normally created to help avert risk, identify critical product characteristics and enabling product requirements, identify control requirements for product integrity, perform sensitivity analyses to establish design margins, provide quantitative performance assessments, and select preferred physical solution representation.	
1) Identify and Define Physical interfaces	Physical interfaces (human, form, fit, function, data flow, and interoperability) among specific physical entities that make up each end product physical solution alternative, among end products that make up the system, among end products and enabling products, and along with end products and other interfacing systems, are identified and defined. Physical interfaces (internal to the system and external) among specific solutions selected for each physical entity that make up the selected physical solution are designed and described.
2) Identify and Analyze Critical Parameters	For each identified key performance parameter (TPM), the variability and the sensitivity of each alternative physical solution to that variability are identified and defined.
3) Identify and assess physical solution options:	
(a) Technology requirements	The technological needs necessary to make each alternative solution effective, the risks associated with introduction of new or advanced technologies to meet requirements, and alternative lower-risk technologies that could be substituted for unacceptable higher risk technologies are identified and assessed.
(b) Off-the-shelf availability	The availability of off-the-shelf end products (non-developmental hardware or reusable software) are identified and assessed.
(c) Competitive considerations	The effect of design considerations to maintain or make a physical solution representation alternative competitive with potential or existing competitor products is identified and assessed.

(d) Failure modes, effects, and criticality	Further design efforts are identified that will be needed to accommodate redundancy and to support graceful degradation when the results of failure modes, effects, and criticality of failure analyses have an unacceptable or high criticality rating.
(e) Performance assessment	The degree to which the performance requirements are satisfied by each alternative physical solution is identified and assessed.
(f) Life cycle considerations	The degree to which producibility, testability, ease of deployment, installability, operability, supportability, trainability, and disposability are considered in each alternative physical solution is identified and assessed. Enabling products needs, requirements and constraints for the associated processes are identified, assessed, and defined.
(g) Capacity to evolve	The capacity of each alternative physical solution to evolve, or be reengineered, incorporate new technologies, enhance performance, increase functionality, or other cost-effective or competitive improvements, once solution end products are in production or in the marketplace, are identified and assessed. Limitations that can preclude the capacity of the system to evolve are identified and documented.
(h) Make vs. buy	The advantages and disadvantages of making the products of the solution within the enterprise or going to an established supplier are identified and assessed.
(i) Standardization considerations	The advantages and disadvantages of using standardized end products, protocols, interfaces, etc., for the physical solution are identified and assessed.
(j) Integration concerns	The following are identified and assessed: (1) potential hazards to other systems, operators, or the environment; (2) built-in test and fault-isolation test requirements; (3) ease of access, ready disassembly, use of common tools, part count effect, advantage of modularity, standardization, and less need for cognitive skills; and (4) dynamic or static conflicts, inconsistencies, and improper functionality of the integrated products of the solution.
4) Perform system analyses	Which physical solution option is best for each alternative solution representation, based on each option individually or in sets (Sub-process 22, 23, and 24) is determined.
d) Identify and define derived technical requirements	Derived technical requirement statements identified and defined that are: (1) the consequence of design choices associated with the above tasks, (2) used to form alternative physical solution representations, as appropriate, and (3) individually and as a set (including physical interface requirements) well formulated (Sub-process 25)
e) Select preferred physical solution	The preferred physical solution representation is selected, based on the results of an evaluation of each physical solution representation (Sub-process 22, 23, and 24).
f) Ensure selected physical solution representation consistency	The selected physical solution representation is determined to be consistent with assigned logical solution representations, derived technical requirements, and the identified subset of unassigned system technical requirements [see the note under Requirement, task 17c)]
g) Record the outcomes of a) through g)	The following are captured in the information database: selected physical solution representation, along with selection rationale, assumptions, and outcomes from tasks a) through g).

Table C.19 – Sub-process 19 (Solution Definition Process – Specified Requirements)

Representative tasks	Expected outcomes
a) Fully characterized design solution	For each specific physical entity of the selected physical solution: hardware drawings and schematics, software design documents, parts lists, interface descriptions, procedural manuals, data or other applicable design descriptions, based on the requirements assigned to the selected physical solution and engineering life-cycle-phase exit criteria, are completed, as applicable.
b) Ensure design solution consistency	The defined design solution is verified as being consistent with the selected physical solution representations as described by its encapsulated requirements for the assigned logical solution representations, associated system technical requirements, and derived technical requirements. Invoked the Verification Process Sub-process 30.
c) Specify requirements	System, subsystem, and interface specifications that describe the specified requirements (functional and performance requirements, and physical characteristics) are documented. Test requirements to ensure that end products satisfy their specified requirements are determined and included in the related specification, as appropriate to the engineering life-cycle phase.
d) Record design solution and related specified requirements	The design solution work products, including the specified requirements, are captured and recorded in the established information database, along with all trade-off analyses, design rationale, assumptions, and key decisions to provide traceability of requirements up and down the system structure.
e) Establish projects for development of enabling products	A project is established to engineer the enabling products associated with the processes for development, production, test, deployment/installation, training, support/maintenance, and retirement/disposal. NOTE – The requirements for enabling products come from: (1) user or customer or assigned requirements and other stakeholder requirements for the system, and (2) derived technical requirements for end products and their subsystems generated by tasks of the Solution Definition Process. Thus, initiation of enabling product development is dependent on the completion of the design solution for the system (building block) being engineered or reengineered.

Table C.20 – Sub-process 20 (Implementation Process)

Representative tasks	Expected outcomes
a) Acquire products (Goods or Services)	Hardware, software, firmware end products, or composites of end products built or coded to their specified requirements, drawings or descriptive documents; or other needed physical entities for example, trained personnel, certified facilities, special techniques (manual procedures or processes), manuals) are acquired. Hardware items are: (1) purchased off-the-shelf from a supplier or vendor; (2) fabricated in-house; or (3) from in-house, off-the-shelf supply. Software items are: (1) purchased from a supplier or vendor; (2) coded in-house; or (3) reused.
b) Validate acquired products	Acquired products are validated that each acquired end product or aggregation of end products is in conformity with its user, customer, or assigned requirements. Invoked in the End Products Validation Process, Sub-process 33. NOTE – This validation is accomplished by the supplier as per the agreement or by the acquirer, with or without supplier participation. This validation includes product certification or acceptance testing, as appropriate.

c) Assemble/integrate validated end products	End products or aggregations of end products already validated are physically integrated or assembled into the required test article or the end product that will be verified and delivered to an acquirer.
d) Verify integrated end products	End products are verified that each end product of the system under development complies with its specified requirements. Invoked the System Verification Process, Sub-process 31: End Product Verification.
e) Verify enabling products for each associated process	Enabling products for production, test, deployment/installation, training, support/maintenance, and retirement/disposal, as appropriate, are verified that they will be ready to perform the support functions required by the system's end products. Associated processes are proofed, as applicable. Invoked the System Verification Process, Sub-process 32: Enabling Products Readiness.
f) Validate the verified end product	End products are validated prior to delivery to their acquirer, if required in the agreement, using the End Products Validation Process, Sub-process 33: End Products Validation.

Table C.21 – Sub-process 21 (Transition to Use Process)

Representative tasks	Expected outcomes
a) Acquire and put in place enabling products	Appropriate enabling products for supporting the Transition to Use Process are acquired and put in place.
b) Prepare end products for shipping or storage	In accordance with the agreement: (1) packing materials and containers are prepared; and (2) end products are packaged and appropriately labeled for either storage or delivery.
c) Store or deliver end products	End products awaiting shipping are appropriately stored or, in accordance with the agreement, delivered to intended usage sites in a condition suitable for application, use, installation, or integration with other end products or composites of end products.
d) Prepare the operational sites	Sites where products will be stored, installed, used, or maintained, or where services will be performed, are prepared, as required by the agreement.
e) Installation of products	End products are installed at appropriate sites, as required by the agreement.
f) Perform commissioning	Delivered or installed products are brought to operational readiness, with appropriate acceptance and certification tests completed, as required by the agreement.
g) Provide ghosting	Parallel operation of a new and legacy end product provides continuing service until the new system is fully on line and accepted by the customer, as required by the agreement.
h) Train users and maintenance personnel	Training of users, operators, maintainers, and other necessary personnel is completed, as required by the agreement.
i) Provide in-service support	In-service support is provided, as required in the agreement.

Table C.22 – Sub-process 22 (System Analysis Process – Effectiveness Analysis)

Representative tasks	Expected outcomes
a) Plan effectiveness analyses	A plan is prepared to include the purpose, objectives, execution and data collection requirements, schedule of tasks, availability of required resources, expected outcomes, and the general approach for required effectiveness analyses.
b) Analyze system cost effectiveness	For each alternative physical solution representation, as well as for the design solution, the system cost effectiveness is determined with respect to the following attributes, as applicable: accuracy, availability, capacity, maintainability, reliability, responsiveness, operability, safety, security, survivability, spare requirements, transportability, vulnerability, etc.
c) Analyze total ownership cost	Costs to the enterprise and to the acquirer for alternative physical solution representations, for alternative trade-off analysis options, or for proposed changes, and the known uncertainties (risks) in these costs are determined. NOTE – The following costs are typically included in a total ownership cost analysis: development, production, test, deployment/installation, training, operations, support/maintenance, and retirement/disposal.
d) Analyze environmental impacts	Applicable federal, state, municipal, and international environmental statutes and applicable hazardous material lists affecting the project and endurance of compliance by each physical solution are determined; the effect on and by each end product and enabling product on the infrastructure, land and ocean, atmosphere, water sources, and animal, plant and human life, as applicable, has been determined, from an enterprise-based life cycle perspective.
e) Analyze system effectiveness	For each operational profile, each alternative physical solution representation and the design solution are assessed by analytic confirmation to satisfy appropriate requirements.
f) Record outcomes of effectiveness analyses	Effectiveness analysis outcomes, as well as the details of the analyses performed, including rationale, assumptions, and lessons learned, are captured and recorded in the established information database.

Table C.23 – Sub-process 23 (System Analysis Process – Trade-off Analysis)

Representative tasks	Expected outcomes
a) Plan Trade-off analysis	A plan is prepared to include: 1) the availability of required resources, level of importance, execution and data collection requirements, expected outcomes, objectives, schedule of tasks, and the type. NOTES – The types of trade-off analyses typically performed include: 1 Formal – formally conducted, with results reviewed at technical reviews. Specific formal trade-off analyses are normally identified in an agreement. 2 Informal – follows the same methodology of a formal trade-off analysis but requires less documentation and is of less importance to the acquirer. 3 Judgmental – selection of a recommended option, based on judgment of the analyst or designer after a less rigorous assessment. 2) Selection criteria that characterize what makes a specific option desirable or undesirable, such as (1) cost, schedule, performance, and risk; (2) life-cycle concerns; (3) –ility concerns (e.g., producibility, testability, maintainability, supportability, disposability); (4) size, weight, and power consumption for the

	type of Trade-off analysis selected; and (5) effectiveness analysis outcomes. 3) weighting factors for each criteria on that will help distinguish its degree of importance for the defined trade-off analysis. 4) applicable models (representative or simulation) that will support conduct of the trade-off analysis, as well as determination that the model selected is valid for the trade-off analysis to be performed. 5) list of viable optional solutions or courses of action to be evaluated.
b) Perform Trade-off analysis	Trade-off analyses are completed according to the plan, with determination of: 1) quantitative basis for evaluating the trade-off analysis options from appropriate effectiveness analysis tasks (Sub-process 22); 2) quantitative assessment of the risk level associated with each option from appropriate risk analysis tasks (Sub-process 24); and 3) collection of data pertaining to each option evaluated and analysis of the data to determine the effect of each option on the system or project if implemented. Determination that the methodologies and data collection were sufficient to support a fair and complete evaluation. 4) Identification and definition of the recommended option based on the comparison of each option and its effects against the established success criteria. 5) Presentation of the recommendations to the appropriate decision maker, as applicable.
c) Record outcomes of Trade-off analysis	Recommendations and the selection, as well as the details of the trade-off analysis performed, including rationale, assumptions, and lessons learned, are captured and recorded in the established project information database.

Table C.24 – Sub-process 24 (System Analysis Process – Risk Analysis)

Representative tasks	Expected outcomes
a) Identify risks	Technical risks, and resulting project risks, are identified, based on exposure to the probability of an undesirable consequence and the effect of that consequence for each trade-off analysis option or each physical solution representation option. Considerations include how expectations from a decision or design selection are affected by (1) commitments resulting from a choice, (2) validity of assumptions, (3) capabilities to implement and control, and (4) other organizational or technical constraints such as resources and time.
b) Characterize risks	Risk causes, possible effects or consequences, likelihood of occurrence, options for dealing with identified risks, how long options are available, and coupling among identified risks are determined.
c) Prioritize risks	Risks that would likely cause harm, would have the greatest effect, and would need immediate attention are prioritized.
d) Evaluate ways to avert risks	The cost, schedule, and performance effects on the project are determined from evaluation of options or courses of action that would (1) eliminate a specific risk possibility; (2) implement acts to reduce a risk's probability or effect; (3) transfer the risk (get someone else to assume the risk, e.g., a warranty); or (4) provide a contingency to address the consequences, if the risk occurs, including identity or appropriate and timely triggers for taking action (will they give sufficient time to act?) such as a metrics or events monitor.

e) Define and implement a plan or approach for averting each significant risk	The significant risks to the project are identified and adequate risk aversion approaches are defined. Triggers are defined that will provide a signal when it is appropriate to implement aversion action. Implemented planned actions or approaches to avert risk.
f) Capture and communicate risk analysis outcomes	The effects of the risk analysis, as well as the details of the risk analysis performed, including assumptions, are captured and recorded in the established project information database. Risks effects have been reported or used, as appropriate.

Table C.25 – Sub-process 25 (Requirements Validation Process – Requirement Statements Validation)

Representative tasks	Expected outcomes
a) Analyze and ensure each technical requirement statement is stated with: 1) ability to preserve competitiveness – permits preservation of a competitive stance and is only as constraining on competitive stance as is justified by benefits delivered by requirement. 2) clarity – requirement statement is readily understandable without analysis of meaning of words or terms used. 3) correctness – requirement statement does not contain an error of fact. 4) feasibility – requirement can be satisfied within (1) natural physical constraints, (2) state of the art as it applies to the project, and (3) all other absolute constraints applying to the project. 5) focus – requirement is expressed in terms of 'what' and 'why', or form, fit and function, not in terms of how to develop the products or the materials to be used – detailed requirements that are required to guide detailed design of a product are an exception to this. 6) implementability – requirement statement contains information necessary to enable requirement to be implemented. 7) modifiability – necessary changes to a requirement can be made completely and consistently 8) removal of ambiguity – allows only on interpretation for meaning of the requirement, e.g., not defined by words or terms such as 'excessive,' 'sufficient,' and 'resistant' that cannot be measured. 9) singularity – requirement statement cannot be sensibly expressed as two or more requirements having different agents, actions, objects, or instruments. 10) testability – existence of finite and objective process with which to verify that the requirement has been satisfied. 11) verifiability – can be verified at the level of system structure at which it is stated.	
b) Analyze and ensure technical requirements statements in pairs and as a set are stated with: 1) absence of redundancy – each requirement is specified only once. 2) connectivity – all terms within a requirement are adequately linked to other requirements and to work and term definitions, so that individual requirements relate properly to other requirements as a set. 3) removal of conflicts – requirement is not in conflict with other requirements or within itself.	

Table C.26 – Sub-process 26 (Requirements Validation Process – Acquirer Requirements Validation)

Representative tasks	Expected outcomes
a) Select methods and define procedures	The methods and procedures for validating the set of defined acquirer requirements are selected and defined, consistent with the level of system structure, enterprise-based life-cycle phase, and Validation Plan, as appropriate.
b) Establish downward traceability	The downward traceability of stated, documented, or otherwise determined, acquirer needs and expectations to the set of defined acquirer requirements is determined.
c) Establish upward traceability	The upward traceability of the individual acquirer requirements, from the set of defined acquirer requirements, to stated, documented, or otherwise captured, acquirer needs and expectations is determined.
d) Identify and resolve variances	Identified voids, variances, and conflicts have been resolved. When the set of defined acquirer requirements is not upward-traceable to acquirer needs and expectations, whether non-sourced (orphaned) requirements or constraints were introduced and whether they are desired by the acquirer, have been determined, and appropriate action has been taken. When acquirer needs and expectations are not reflected in the set of defined acquirer requirements, the omitted needs and expectations are added to the set of defined acquirer requirements, as appropriate.
e) Record validation results	Validation procedures, outcomes, assumptions, corrective actions, lessons learned, etc., are captured and recorded in the established information database.

Table C.27 – Sub-process 27 (Requirements Validation Process – Other Stakeholder Requirements Validation)

Representative tasks	Expected outcomes
a) Select methods and define procedures	The methods and procedures for validating the set of defined other stakeholder requirements are selected and defined and are consistent with the level of system structure, enterprise-based life-cycle phase, and Validation Plan, as appropriate.
b) Establish downward traceability	The downward traceability of stated, documented, or otherwise determined, other stakeholder needs and expectations to the set of defined other stakeholder requirements is established.
c) Establish upward traceability	The upward traceability of the individual other stakeholder requirements, from the set of defined other stakeholder requirements, to stated, documented, or otherwise captured, other stakeholder needs and expectations is established.
d) Identify and resolve variances	Identified voids, variances, and conflicts are resolved. When the set of defined other stakeholder requirements was not upward-traceable to other stakeholder needs and expectations, whether non-sourced (orphaned) requirements or constraints were introduced, has been determined, and appropriate actions were taken to eliminate non-sourced requirements. When other stakeholder needs and expectations were not reflected in the set of defined other stakeholder requirements, omitted needs and expectations were added to the set of defined other stakeholder requirements, as appropriate.
e) Record validation results	Validation procedures, outcomes, assumptions, corrective actions, lessons learned, etc., are captured and recorded in the established information database.

Table C.28 – Sub-process 28 (Requirements Validation Process – System Technical Requirements Validation)

Representative tasks	Expected outcomes
a) Select methods and define procedures	The methods and procedures for validating the set of defined system technical requirements are selected and defined and are consistent with the level of system structure, enterprise-based life-cycle phase, and Validation Plan, as appropriate.
b) Establish downward traceability	The downward traceability of the validated sets of stakeholder (acquirer and other stakeholder) requirements to the set of defined system technical requirements is determined.
c) Establish upward traceability	The upward traceability of the individual system technical requirements, from the set of defined system technical requirements, to the validated sets of stakeholder requirements is determined.
d) Analyze assumptions	Assumptions regarding consistency of the system technical requirements with the system being engineered are determined.
e) Analyze other system technical requirements	Other system technical requirements derived as essential to design and subsequent life cycle-phases are consistent with the system being engineered and other system technical requirements are determined.
f) Identify and resolve variances	Identified voids, variances, and conflicts are resolved. When the set of defined system technical requirements was not upward-traceable to validated sets of stakeholder requirements, whether non-sources (orphaned) requirements or constraints were introduced was determined, and appropriate actions to eliminate non-sourced requirements or revised the appropriate set of stakeholder requirements were taken. When validated stakeholder requirements were not reflected in the set of defined system technical requirements, omitted requirements were added to the set of defined system technical requirements or determine the need for the requirement, as appropriate.
g) Perform revalidation	When a change is needed to one of the validated sets of stakeholder requirements, the appropriate tasks of acquirer or other stakeholder requirements definition from the Requirements Definition Process were accomplished and the set was revalidated. When the set of system technical requirements must be changed, the appropriate tasks of system technical requirements definition from the Requirements Definition Process were reaccomplished and the set was revalidated.
h) Record validation results	Validation procedures, outcomes, assumptions, corrective actions, lessons learned, etc., are captured and recorded in the established information database.

Table C.29 – Sub-process 29 (Requirements Validation Process – Logical Solution Representations Validation)

Representative tasks	Expected outcomes
a) Select methods and define procedures	The methods and procedures for validating the defined sets of logical solution representations and derived technical requirements are selected and defined and are consistent with the level of system structure, enterprise-based life-cycle phase, and Validation Plan, as appropriate.
b) Establish downward traceability	The downward traceability of the validated set of system technical requirements to each set of logical solution representations and the derived technical requirements is determined.
c) Establish upward traceability	The upward traceability of individual logical solution representations from a set of logical solution representations and the derived technical requirements to the validated set of system technical requirements is determined.

d) Analyze assumptions	Assumptions made while defining the sets of logical solution representations to ensure that they are consistent with the system technical requirements and the system being engineered are assessed and considered valid.
e) Identify and resolve variances	Identified voids, variances, and conflicts are resolved. When validated system technical requirements are not reflected in a set of logical solution representations, omitted requirements are added to the set of logical solution representations. The need for added requirements is confirmed, and it is determined whether these requirements were to be assigned directly to physical solutions. When a set of logical solution representations is not upward traceable to the validated set of system technical requirements, it is determined whether non-sourced (orphaned) requirements and constraints have been introduced. Appropriate actions are taken whether to eliminate non-sourced requirements, to establish derived requirements, or to revise the set of system technical requirements.
f) Perform revalidation	When a change is needed to the validated set of system technical requirements, the appropriate tasks from the Requirements Definition Process are reaccomplished and the set is revalidated. When one or more sets of logical solution representations has to be changed, the appropriate tasks for definition of logical solution representations from the Solution Definition Process are reaccomplished and the set was revalidated.
g) Record validation results	Validation procedures, outcomes, assumptions, corrective actions, lessons learned, etc., are captured and recorded in the established information database.

Table C.30 – Sub-process 30 (System Verification Process – Design Solution Verification)

Representative tasks	Expected outcomes
a) Plan the design solution verification in accordance with the Verification Plan, the agreement, and the applicable enterprise-based life cycle-phase, and level in the system structure	1) The appropriate method needed to verify the system's fully characterized design solution is identified and defined NOTE – Design solution verification methods include: inspection (for example, inspection of drawings), analysis (for example, using simulation or virtual reality prototype), demonstration (for example, using mockups or physical models), or test (for example, by testing physical prototypes, breadboards, or brassboards). 2) Verification procedures are defined, based on (1) procedures for each method selected, (2) purpose and objective of each procedure (3) pre-test and post-test actions, and (4) criteria for determining the success or failure of the procedure 3) The verification environment (for example, facilities, equipment, tools, simulations, measuring devices, personnel, and climatic conditions) in which the verification methods and procedures will be implemented is established and checked-out for adequacy, completeness, readiness, and integration.
b) Perform the planned design solution verification using selected methods and procedures within the established verification environment	Verification outcomes to show completion of verification objectives and to determine untraceable requirements and constraints, voids, conflicts, variations and anomalies are collected and evaluated. Specifically, it was shown that: 1) the system design solution descriptions and interfaces (internal or external) are upward-traceable to requirements of the selected physical solution representation; 2) source requirements are downward-traceable to the system design solution descriptions; 3) the design solution satisfied the functional and performance requirements of the identified subset of unassigned system technical (see note under Sub-process 17 c) and the set of derived technical requirements;

	4) intended functions are correctly implemented; 5) constraints, including interfaces, are satisfied. When defined variances were not downward-traceable from source documents, appropriate tasks of the Requirements Definition and Solution Definition Processes were repeated to correct the omissions. When defined variances showed inconsistencies with source requirements (not upward-traceable), the following were determined: why new requirements were introduced, and if they were to be assigned as derived technical requirements, were to be removed from the design solution definition, or had to be reflected in the set of logical solution representations or set of system technical requirement. The necessary tasks of the Requirements Definition and Solution Definition Processes were reaccomplished as required for corrections and reverifications.
c) Perform reverification	When test outcome variations and anomalies were traced to poor verification conduct or to inadequate verification environment, verifications are repeated to obtain valid outcomes.
d) Record verification results	The verification procedure, together with the outcomes achieved, variations, corrective actions taken, rationale justifying the design solution, trade-off analyses and effectiveness analyses completed with resulting key decisions, verified design solution definition, lessons learned, etc., are recorded in the project information database according to the verification plan and test procedure requirements. NOTE – The verified design solution and its related specified requirements are placed under configuration management control.

Table C.31 – Sub-process 31 (System Verification Process – End Product Verification)

Representative tasks	Expected outcomes
a) Plan the end product verification in accordance with the Verification Plan, the agreement, and the applicable enterprise-based life cycle-phase, and level in the system structure	1) The appropriate methods needed to verify the system's end products against their specified requirements are selected and defined. NOTE – Design solution verification methods include: inspection (for example, inspection of drawings), analysis (for example, using simulation or virtual reality prototype), demonstration (for example, using mockups or physical models), or test (for example, by testing physical prototypes, breadboards, or brassboards). 2) Verification procedures are established and based on (1) procedures for each method selected, (2) purpose and objective of each procedure, (3) pre-test and post-test actions, and (4) criteria for determining the success or failure of the procedure. 3) The verification environment (for example, facilities, equipment, tools, simulations, measuring devices, trained personnel, special techniques, and climatic conditions) in which the verification methods and procedures will be implemented is established and checked out for adequacy, completeness, readiness, and integration. 4) Test articles are on hand, assembled, and integrated with the verification environment according to the verification plans and schedules, and appropriate sets of specified requirements are available.
b) Perform the planned end product verification using selected methods and procedures	Verification outcomes are collected and evaluated to show completion of verification objectives and used to determine 1) variations and anomalies, and out-of-compliance conditions; 2) data quality, integrity, correctness, consistency , and validity; 3) whether fabricated, integrated, or purchased end products (including end

within the established verification environment	products, composites of end products, or software or firmware builds) comply with their respective specified requirements; 4) that end product test articles were appropriately integrated with the test environment and each requirement was properly tested for; and 5) that system end products function together and with interfacing products throughout their performance envelope. For variations and anomalies not caused by poor test conduct, or conditions, appropriate tasks of the processes in this Guide, including replanning, changing requirements, redefining requirements, and the design solution, and verification, are accomplished to resolve discrepancies.
c) Perform reverification	When test outcome variations and anomalies were traced to poor verification conduct or to inadequate verification environment, end product verification is reaccomplished.
d) Record verification results	The verification methods and procedures, together with the outcomes achieved, variations and anomalies, corrective actions taken, rationale justifying corrections, trade-off analyses, and effectiveness analyses completed with resulting key decisions, lessons learned, etc., are recorded in the project information database according to the verification plan and test procedure requirements. Recorded test result data includes the following: 1) The version of the set of specified requirements (specifications) used. 2) The version of the end product tested. 3) The version or reference standard for tools and equipment used, together with applicable calibration data. 4) The results of each test including pass or fail declarations. 5) The discrepancy between expected and actual results. 6) A statement of success or failure of the testing process, including its relation to the verification process. Deliver or disposition of verified compliance articles and compliance data is completed in accordance with the acquirer-supplier agreement, verification plan instructions, or project directives or procedures.

Table C.32 – Sub-process 32 (System Verification Process – Enabling Product Verification)

Representative tasks	Expected outcomes
a) Plan the enabling product readiness determination in accordance with the agreement, and the applicable enterprise-based life cycle-phase, and level in the system structure	1) The appropriate methods needed to determine enabling product readiness and maturity of development, based on the applicable enterprise-based life-cycle phase and level in the system structure, the purpose and objective of each method selected, the appropriate plan, and the acquirer-supplier agreement, are selected and defined. 2) Procedures based on (1) each method selected, (2) purpose and objective of each method, (3) pre-test and post-test actions, and (4) criteria for determining the success or failure of the method are established. 3) The environments (for example, facilities, equipment, tools, simulations, measuring devices, trained personnel, special techniques, and climatic conditions) in which the methods and procedures will be implemented is established and checked out for adequacy, completeness, readiness, and integration. 4) Required information regarding the status and maturity of enabling product development or requirements definition is on hand. Non-developmental enabling products are on hand and integrated appropriately.
b) Perform the planned enabling product readiness	Outcomes are collected and evaluated, and any enabling product readiness anomalies, variations, or out-of-compliance conditions (such as lack of requirements for manuals or training equipment or disposal of hazardous materials) are discovered.

determination, using selected methods and procedures	The following have been determined 1) whether development for required enabling products is progressing satisfactorily or will be ready to perform its life cycle function when needed or if there are out-of-compliance conditions. 2) that plans and selected methods, procedures, and tools for each associated process can accomplish their intended purpose 3) whether the development is on schedule and that the schedule meets critical end product needs 4) the interfaces between planned enabling products and their intended end products have no potential conflicts in implementation concepts, intended functions, or interdependencies 5) that enabling products meet the requirements of the end products or composites of end products they are intended to support. For variations and anomalies not caused by poor readiness assessments, appropriate tasks of the processes in this Guide, include replanning, changing requirements, redefining requirements and the design solution, and readiness determination, are accomplished to resolve discrepancies.
c) Reaccomplish readiness determination	For discrepancies caused by poor readiness assessment, the appropriate tasks of enabling product readiness determination are reaccomplished.
d) Record readiness determination results	Enabling product readiness determination outcomes are recorded in the information database.

Table C.33 – Sub-process 33 (End Products Validation Process)

Representative tasks	Expected outcomes
a) Determine validation exit criteria	The type of validation required and the requirements to be used are determined. The types include: (1) validation against acquirer requirements in the anticipated usage environment, with test conditions that span the expected range of actual operating conditions, to the extent practical, and in conjunction with stakeholders, as appropriate; (2) certification tests against established certification requirements; (3) acceptance tests using operational processes and personnel in operational environments; or (4) as specified in the agreement. NOTES 1 Validation tests are conducted during the Test and Evaluation Phase of the engineering life cycle, after the end products have been verified against specified requirements, from the lowest level of the system structure upward to the end products that will be delivered to the marketplace to satisfy validated acquirer requirements. 2 Validations of Types 1 through 3 are satisfied with the same tests, when appropriate. 3 Validation can be for a single end product or an aggregation of end products for the same building block.
b) Acquire appropriate test article	The test article, or test articles, used for the validation is determined to be appropriate to the enterprise-based life-cycle phase and the level of system structure. NOTE – End Products Validation consists of one or more tests using a version of the product (or products) as nearly like the final version as is practical and

	necessary, taking into account the enterprise-based life-cycle phase and the nature of the product. If the nature of either product, its operating conditions, or the enterprise-based life-cycle phase of development precludes use of actual products or prototypes, then breadboards, brassboards, hardware-in-the-loop simulations, virtual-reality simulations, or other models and simulations are applicable for End Products Validation.
c) Conduct validation	1) Validation is completed in accordance with the Validation Plan, as required in the agreement. 2) Validation outcomes are compiled, analyzed, and compared to the validation exit criteria; variations and anomalies have been identified; and corrective actions are defined. 3) When outcome variances from exit criteria were not caused by improper test conditions, by improper performance of validation procedures, or by improper data collection: Replanning, redefinition of the design solution, and the Implementation Process, as appropriate, are reaccomplished. NOTE – Care is to be taken to ensure that the requirements derived to remove variances do note conflict with acquirer or other stakeholder requirements, or other validated technical requirements without coordinating such change with the appropriate stakeholders.
d) Perform revalidation	If variances were caused by poor test conduct, retesting, using improved or correct test equipment and procedures, is performed.
e) Record validation results	Validation procedures, compliance data, outcomes, assumptions, corrective actions, lessons learned, etc., are recorded in the established project information database.

Appendix D – Planning Documents (informative)

This Appendix provides an informative list of typical documents and their contents taken from various commercial and non-commercial domains. Selection and use of these documents depends on agreement requirement and the nature and scope of the project.

D.1 Source Documents

1. During early phases of the enterprise-based life cycle, system concepts are often vague and unstructured. Typical concept source documents include:

    a) *Concept Specification*. This includes a features list for a new or improved system or product. It identifies the scope of the features and their priority to provide an edge in the market.

    b) *Maintenance Concept*. This focuses on life cycle logistics goals, objectives, constraints, and general support capabilities related to a desired system or product.

    c) *Operations Concept (or Concept of Operations)*. This focuses on the goals, objectives, and general desired capabilities of a potential system or product (new or improved), without indicating how the system or product can be implemented.

    d) *Disposal Concept*. This focuses on the planned disposition of the end products, and by-products produced throughout the life cycle of the system.

    e) *Request for Proposal (RFP)*. This can include one or more of the above initiating documents. Its purpose is to solicit bids for consideration from several sources to develop a system or product.

2. For creation activities (system definition, subsystem design, detailed design and integration, and test and evaluation) of the engineering life cycle, source documents are much more definitive and include one or more of the following:

    a) *Contract.* This type of negotiated document is the basis for most project efforts involving two enterprises. It often includes the Operations Concepts, Maintenance Concept, Statement of Work, performance specifications, drawings, and interface control documents.

    b) *Statement of Work (SOW).* This provides requirements for the technical work to be accomplished by an assigned team or project. It is provided as part of a contract or internal tasking document.

    c) *Tasking Document.* This is a type of an agreement between two parties, typically inside an enterprise.

D.2 Technical Documents

Technical documents are dependent on the applicable enterprise-based life-cycle phase and describe the technical efforts in a particular area to be accomplished during engineering life cycle activities. Technical documents are usually prepared by the project during an earlier enterprise-based life cycle activity. They also can be included in source documents when prepared by the acquirer, either internal or external.
Technical documents include (alphabetically):

1. *Configuration Management (CM) Plan*. This document defines the process used to identify and document the functional and physical characteristics of the system during its life cycle. The CM process provides a means of controlling changes to those characteristics and provides information on the status of changes. (See ANSI/EIA-649, *National Consensus Standard for Configuration Management.)*

2. *Contractor Integrated Technical Information Services (CITIS) Plan.* This document describes the methods that allow access and delivery of required digital information to an external acquirer.

3. *Data Management Plan.* This document reflects the data requirements of an agreement; establishes data management criteria and responsibilities; and describes the enterprise structure, administration, and control procedures used to ensure effective data management (internally as well as with external acquirers or suppliers).

4. *Electromagnetic Compatibility/Interference (EMC/EMI) Control Plan.* This document presents the methods that allow the project to meet the EMC/EMI requirements related to the system, including, as appropriate, susceptibility to electromagnetic pulse from nuclear weapons. It communicates the work effort, the emphasis, and the design guides to be used in avoiding serious electromagnetic compatibility problems. It provides guidance to assigned teams on design, specifications, and installation parameters so as to ensure a system that is compatible with upper-layer and lateral end products and enabling products, and with external systems.

5. *Engineering Plan.* The engineering plan provides, to project personnel and the acquirer, the planned technical efforts to accomplish the processes for engineering a system for the applicable enterprise-based life-cycle phases of the project. The engineering plan provides (1) an understanding of the problem to be solved, (2) what is planned to be accopmplished, (3) how it will be done, (4) who will do it, (5) where and when things will be done, and (6) resources required, including when, how much, and charcteristics. The focus of this plan is on risk reduction. This plan need not be a stand-alone document but can be part of the project plan. In military projects, this plan is often called the *Systems Engineering Plan* (SEP).

6. *Human Factors/Engineering Plan.* This document focuses on human factors engineering so that the best human performance is obtained in the operation of the highly complex equipment developed by a project. This plan is built on the assumption that the capacities of humans lie within certain limits and that by adapting the design of an end product for humans requires consideration of basic human characteristics: decision-making capability; muscular strength and coordination; body dimensions; perception and judgment; skills; optimum work load; and requirements for safety, comfort, and freedom from environmental stress.

7. *Interface Control Plan.* This document identifies and defines the physical, electronic, and content characteristics of all system internal and external interfaces and communications links. It ensures that the various elements of the system are functionally, physically, and electronically capable of interacting with each other, and with all external links with which they must connect or communicate, to perform required functions. This includes interfaces with people as well as hardware and software.

8. *Supportability Plan.* This document is meant: to influence the end product design solution definition activities to consider supportability requirements; to identify the support problems and items that drive the cost of support early enough to change the design to fix or eliminate the support problems; to develop a complete set of projections of all resources required to support the end products over their life time; and to develop and use a single database for all analysis.

9. *Maintenance Plan.* This document emphasizes: understanding system readiness and performance requirements, physical environments, and resource availability to support the mission and purpose of the end products; managing the contributions to end product maintainability that are made by enabling products; developing robust end products that are insensitive to the environment experienced throughout the end product's life cycle and that are easily repaired under adverse conditions; and determining spares requirements.

10. *Producibility Plan.* This document has as its objective the achievement of a producible design solution definition at the lowest possible cost while maintaining the functional integrity and quality standards of system products. It includes planning for the analysis and coordination of internal-supplier and

external-supplier engineering, manufacturing, and procurement, and provides an orderly transition from development to production. Producibility emphasizes elimination of undesirable production features involving number of parts, materialism, raw material forms, fabrication processes, tooling, and facilities.

11. *Reliability Plan.* This document has as its purpose the prevention, detection, and correction of design anomalies, weak parts, and workmanship defects.

12. *Software Development Plan.* This document describes a developer's plan for conducting a software development effort, whether for a new development, modification, reuse, reengineering, maintenance, or for all other activities resulting in software products. It includes the software development process to be used, the activities to be performed in each software build, and methods to be used.

13. *Specifications.* As a function of engineering life cycle activities, two kinds of specifications can be available—performance specifications and detail specifications. Performance specifications are outputs of the Solution Definition Process during the Pre-System Definition phase of the engineering life cycle and at least through the Subsystem Design phase. Performance specifications generally are stated in form, fit, and function terms. They can designate the means for verifying compliance. Detail specifications are typically an output of the detailed design activity, especially during development of lower-layer building block product designs. Detail specifications generally state requirements, characteristics, and materials related to a specific solution or approach, thus reducing developer flexibility. Both kinds of specifications can be included in a government contract or can be provided by the user, prime contractor, or another project.

14. *System Safety Plan.* This document has the objective of identifying, evaluating, eliminating, or controlling hazards throughout a product's life cycle. This plan is used to increase safety awareness within assigned teams and to design safety into end products.

15. *System Security Plan.* This document has the objective of identifying, evaluating, eliminating, or controlling security concerns. This plan is used to increase security awareness and bring about the design of security features that will a) reduce an organization's liability, b) address privacy issues, and c) correctly assist in preserving system operations and maintain system integrity when accidental or malicious fault events occur.

16. *Testability Plan.* This document is the basic tool for establishing and executing an effective testability program. This plan emphasizes: integration of testability requirements with other design requirements and dissemination to assigned teams and external suppliers; establishing control for ensuring that each supplier's testability practices are consistent with end product requirements; identifying testability design guides and testability analysis models and procedures to be used by teams; planning for review, verification, and use of testability data submissions; and establishing the testability tasks that are to be done, how each task is to be done, when they are to be done, and how the results of the tasks are to be used.

17. *Training Plan.* This document establishes the personnel and training requirements; describes the supplier-provided training courses by type to establish skill levels to effectively perform operations and support activities; and identifies resources and supporting actions required for establishment and support of the training courses.

18. *Other technical plans.* The above list of technical plans is not meant to be exhaustive. This Guide calls for other plans such as *Verification Plans, Validation Plans, and Test Plans* for which much of the information in the *Testability Plan* would be included for any one or a group of specific tests; and a *Technical Performance Measurement Plan (TPM).* Other technical plans that can be applicable to a project include: *Computer Resource Development Plan, Manufacturing Plan, Mass Properties Management Plan, and Test and Evaluation Management Plan (TEMP).*

D.3 Enterprise or project Documents

Enterprise or project documents provide directive and constraining inputs to the Planning Process. These documents include:

1. *Enterprise Policies*. Policy documents provide a framework for decision making in the conduct of a project and the engineering of systems. Policies establish the criteria by which decisions are made in planning particular areas of an engineering effort as well in implementing an engineering effort. For instance, a policy could state that this Guide must be used for planning all enterprise project activities; or, that engineering efforts are to be accomplished using teams within the project-organizing structure; or, that projects are to use a particular automated tool to accomplish a certain task or set of tasks within the processes for engineering a system; or, the frequency of reporting progress or making progress checks.

2. *Enterprise or project Procedures*. Procedure documents contain the recommended processes, approach, or steps to be taken in completing an agreement for engineering a system. Examples of procedures are: how reports are approved; or, how technical reviews are planned, conducted, and closed; or, the activities involved with planning, conducting, and reporting qualifying tests or validations.

3. *Project Plan*. This document provides the considered management approach to meet the requirements of an agreement. It lays out resource availability as a function of time and other key development schedule requirements. It also provides the budget over the projected suppliers. This plan establishes the necessary boundaries for the engineering plan and other technical plans. In military projects, this plan often takes the form of an Integrated Master Plan(IMP) and Integrated Master Schedule (IMS).

4. *Resource Management Plan*. This document can contain: staffing availability, manpower loading limitations, delivery schedule dates, facility availability dates, capacity restrictions, and use of particular materials or reusable hardware or software units. These constraints provide process and design limits, based on enterprise and project resource availability or policies.

5. *Risk Management Plan*. This document describes the project aspects of risk identification (sources and causes), risk characterization (effects, probabilities, choices, time frame, and coupling), risk prioritization (greatest harm, greatest effect, and time urgency), and risk aversion (mitigation, avoidance, transfer, and acceptance). It identifies the risk management functions to be performed by assigned teams and by supporting analysts and specialists. The acceptable levels of risk for a particular enterprise-based life-cycle phase, or group of phases, are included.

6. *Strategic Plan*. This document provides insight into the projects and the markets the enterprise plans to pursue over a given time frame. The Strategic Plan establishes the desired enterprise direction, key objectives, strategies for attaining the objectives, and metrics by which progress toward meeting objectives is measured. It presents how the enterprise plans to compete to obtain a competitive advantage to outperform competitors. Plans for an engineering effort are to be consistent with and support the strategic plan.

7. *Total Cost of Ownership Plan*. This document describes the time-phased technical efforts required to control the total ownership cost, and hence, the affordability, of a system under development. The ultimate cost of a system and its products is locked-in very early in the enterprise-based life cycle and with each application of development life-cycle processes. This document, therefore, discusses the enterprise’s or project’s plan for equating cost with performance and schedule requirements in evolving the system design; for balancing the future costs of production, operation, support, training, and disposal; and for taking active measures for meeting affordability objectives. Specifically, the cost of personnel and consideration of system complexity, open system architectures, reuse, and other such cost-saving approaches are included in the plan.

Appendix E – System Technical Reviews (informative)

The system technical reviews of Table E.1 are related to engineering life-cycle phases and are relevant to the system element of applicable building block developments. They are not directly related to enterprise-based life-cycle phases (see Appendix B); however, technical review exit criteria include satisfying the exit criteria of the applicable enterprise-based life-cycle phase.

System technical reviews for a building block development can be formal (i.e., required by the external customer agreement). Incremental technical reviews for the subsystems, associated processes, and end products are generally informal, not requiring external customer participation on the reviewing body, and are normally conducted prior to the system technical review. System technical reviews for lower-layer building block developments are generally informal unless required to be formal in an agreement.

Table E.1 – Sytem technical reviews

PHASE	ENGINEERING LIFE-CYCLE-PHASE REVIEWS
Pre-System Definition	An *alternative system review*, if applicable, considers all concepts looked at and selects a preferred concept for further development that has the potential for satisfying identified stakeholder requirements. Assesses progress toward converging on a viable, traceable set of system technical requirements that are balanced with cost, schedule, and risk.
System Definition	A *system requirements review* validates that the set of stakeholder requirements is complete, consistent with acquirer's intent, and understood by the developer. A *system definition review* demonstrates convergence on and achievability of technical requirements and readiness to initiate the Subsystem Design Phase.
Subsystem Design	A *Subsystem requirements review*, held for each subsystem-layer building block development, validates that the set of assigned and other local stakeholder requirements is complete, consistent with stakeholder's intent, and understood by the developer. A *system preliminary design review* for each subsystem building block development confirms that: a) subsystem building block specifications have been defined appropriately; b) subsystem building block end product designs satisfy requirements assigned from the parent building block; c) enabling products for the associated processes have been defined adequately to initiate enabling product developments; d) the approaches planned for next lower-layer building blocks are appropriately planned; e) lower-layer building block project risks are identified, and mitigation plans are feasible and judged to be effective.
Detailed Design	A *system detailed design review* for each lower-layer building block development demonstrates that a) specifications and/or drawings or software development files have been appropriately defined; b) the building block end product designs satisfy requirements assigned from the

	parent building block; c) enabling products for the associated processes have been defined adequately to initiate enabling product developments; d) the building block project is either: (1) ready for continued development; (2) appropriately defined for purchase of products form an external supplier; (3) ready for fabrication of building block elements; or (4) adequately defined so that off-the-shelf products or reuse products can be used to fulfill product requirements and are available within the enterprise.
End Product Physical Integration, Test and Evaluation	*Readiness reviews* for each building block from the bottom up demonstrate that delivered end products from lower-layer building blocks have been validated, or that validation tests are adequately planned, and that each set of integrated products forms a composite end product verification and end product validation, if required. *Audits* are intended to: a) demonstrate that end product verification is compliant with their specified requirements and confirms that product verification outcomes compare favorably against configuration documentation: (1) drawings; (2) test procedures; (3) authorized changes; (4) software development files; and (5) “as-built” or “as-coded” documentation; b) confirm that the “as-built or “as-coded” configuration has been favorably examined against its configuration documentation: (1) drawings: (2) bill of materials; (3) specifications; (4) code lists; (5) manuals; (6)compliance test; or (7) compliance data. Additionally, *audits* confirm that: a) products have been built to drawings and satisfy specifications; b) the information database represents the work products of the building block development; c) required changes to previously completed specifications have been implemented; and d) enabling products for down-stream associated processes are available, can be executed, and meet stakeholder requirements. *Process reviews* demonstrate that development of enabling products for associated processes is on schedule, and that designs satisfy related end product needs. Production readiness reviews and test readiness reviews are examples of process reviews

Appendix F – Process Relationships (informative)

The generation and use of various requirements and representations are introduced in Subsection 4.3. These are further described below. Figure F.1 shows the relationship of these requirements.

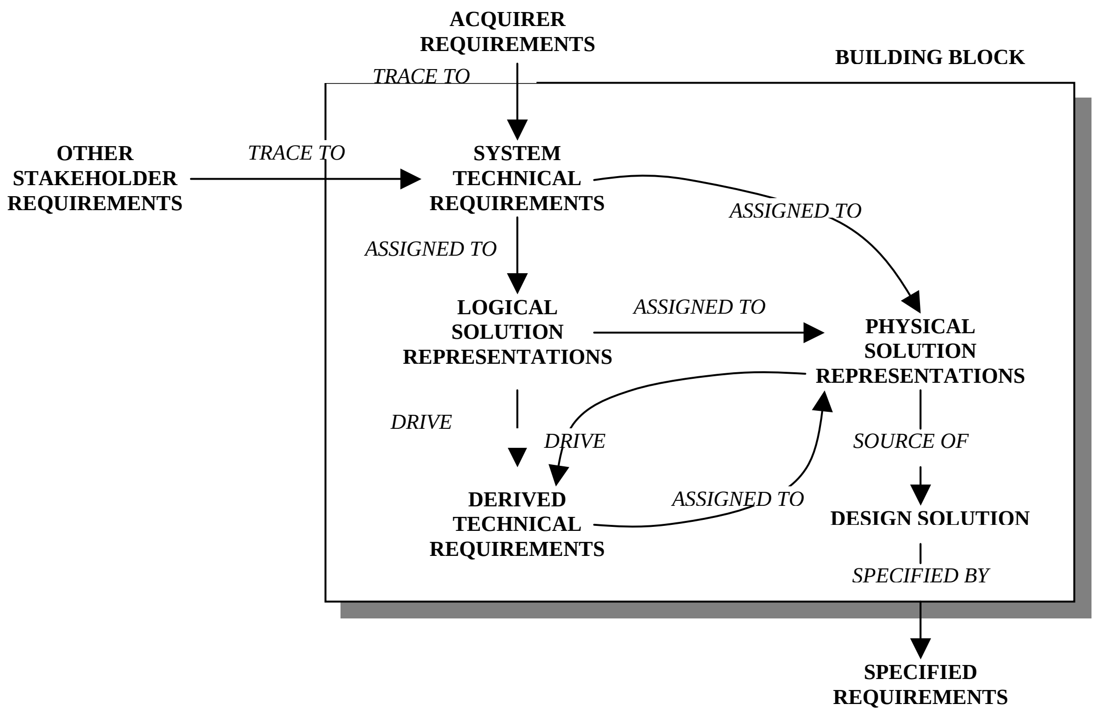


Figure F. 1 – Requirement relationships

Acquirer requirements come from a customer or user (including operators, where applicable) for a major system such as an aircraft, automobile, check processor, mail sorter, or telecommunication switch. Acquirer requirements also come form a developer needing subsystems to make up an end product of a system (see Subsection 6.2). The latter are identified as *assigned requirements* and would have been defined by a prior application of the System Design processes of Subsection 4.3.

Other stakeholder requirements, when added to the acquirer requirements, make up a set of stakeholder requirements that are transformed into system technical requirements. Stakeholder and system technical requirements are identified, collected, or defined by completing the Requirements Definition Process (Subsection 4.3).

The logical and physical solution representations, derived technical requirements, design solution and specified requirements are defined by completing the Solution Definition Process (Subsection 4.3).

Stakeholder requirements (acquirer and other stakeholder requirements), as well as system technical requirements and the derived technical requirements, differ from specified requirements.

1) In effect, stakeholder requirements constitute the input that establishes the problem to be solved. Such requirements can be considered as the initial specification for a development effort or as a set of specified requirements for procuring an off-the-shelf item. End products developed or purchased, and that are to be or that have been delivered to an acquirer, are validated against these specifications (see Sub-process 33).

2) The derived technical requirements, logical solution representations, and system technical requirements reflect intermediate evolution states that are technical in nature, are validated, and are measurable. The design solution is verified against these requirements as reflected by the selected physical solution representation (see Sub-process 30).
3) Specified requirements constitute the controlled definition of the finished solution. These requirements have two roles (see Figure F.2). The first role is to represent the build-to, buy-to, or assemble and integrate-to specifications, drawings, parts lists, etc., that describe the design solution of the product will be verified (see Sub-process 31). The second role is to represent the assigned requirements to be used to develop the subsystems of the end products that require further development.

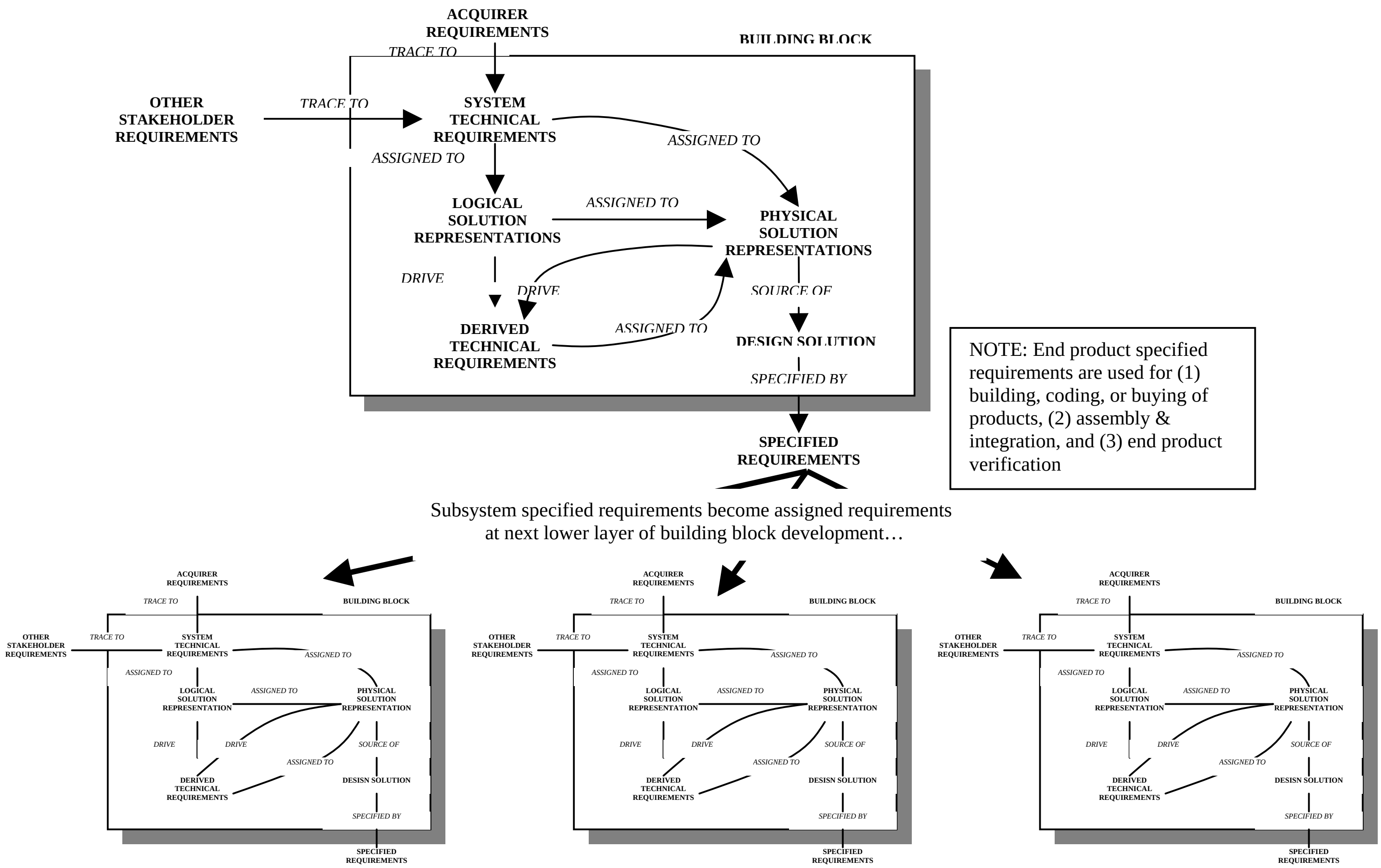


Figure F.2 – Role of specified requirements

Enabling product requirements are generated during the application of the Requirement Definition and Solution Definition processes to the system, end product, and subsystem elements of the building block (see Subsection 6.1). These requirements are not shown in Figure F.1 since they become the basis for another building block development that uses these requirements as assigned requirements. An example of the development of two of the seven associated process enabling products is shown in Figure F.3. The relationships between the types of requirements and the processes and process requirements of this Guide are shown in Figure 4.3c of Section 4.3.

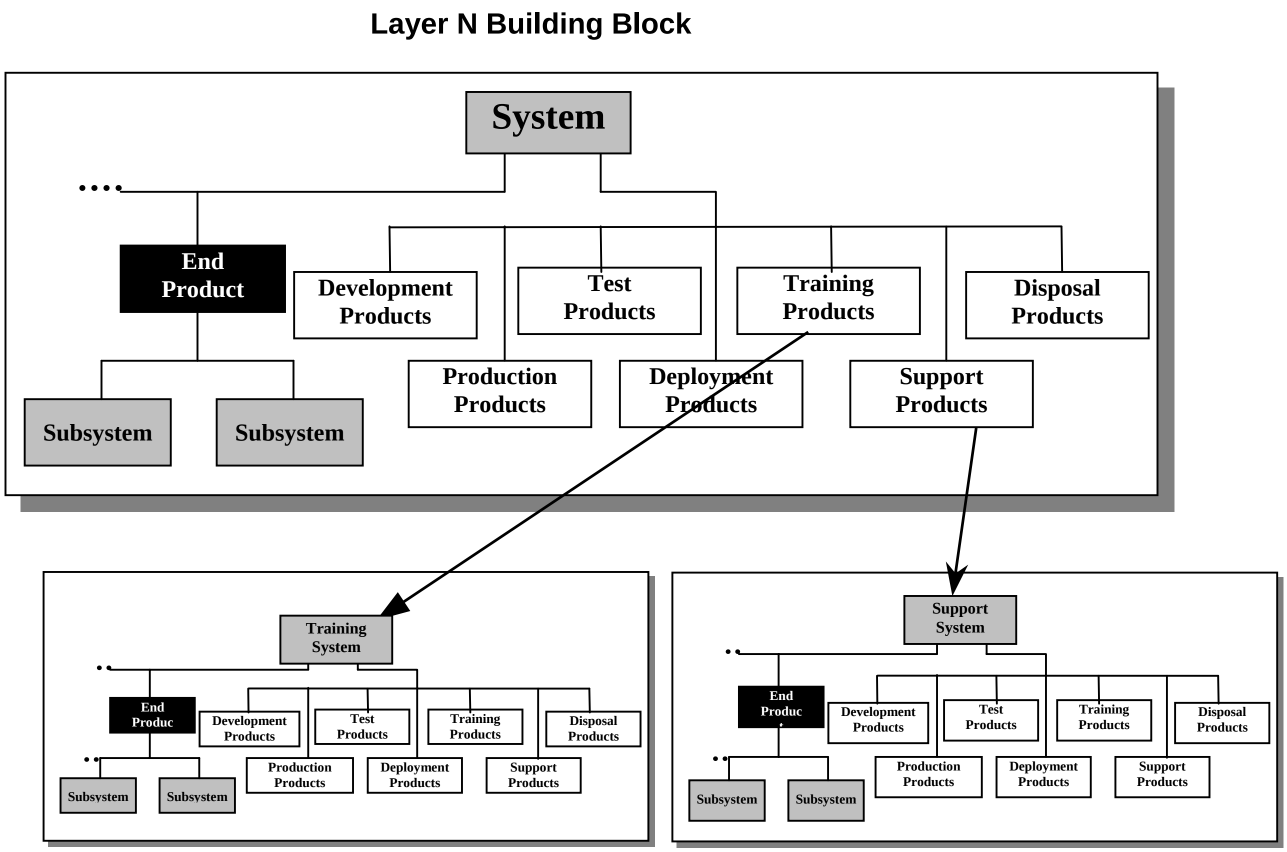


Figure F.3 – Development of enabling products

Appendix G – Engineering Specialty References

ENGINEERING SPECIALTY TABLE

TECHNICAL DISCIPLINE	REFERENCE
Abbreviations	ASME Y14.100 ASME Y14.38M
Acquisition Logistics Handbook	MIL-HDBK-502
Asynchronous Transfer Mode (ATM)	MIL-STD-188-176
Climatic information	MIL-HDBK-310
CM Munitions & Computer Programs (CANCELLED)	MIL-STD-483
Computer aided acquisition and logistics support	MIL-HDBK-59
Configuration Management (CANCELLED)	MIL-STD-973
Configuration Management (CANCELLED)	MIL-STD-2549
Configuration Management Guidance	MIL-HDBK-61
Corrosion prevention and control	MIL- HDBK -1250 MIL- HDBK -1568
Cost Engineering	MIL-HDBK-1010A
Defense Specifications	MIL-STD-961
Defense STDS & HDBKS	MIL-STD-962
Design to Cost (CANCELLED)	MIL-STD-337
Digital Data Bus	MIL-STD-1553B
Digital Nautical Chart (DNC)	MIL-PRF-89023
Electromagnetic compatibility	MIL-STD-1541 MIL-STD-464 MIL-HDBK-237
Electromagnetic Emissions	MIL-STD-461
Electronic Reliability Design	MIL-HDBK-338
Electrostatic Discharge	MIL-STD-1686
Engineering Drawing Practices	MIL-STD-100
Engineering Management (CANCELLED)	MIL-STD-499
Environmental analysis	MIL-STD-810
Fiber Optic Data Bus	MIL-STD-1773
Grounding for Communications Systems	MIL-STD-188-124
Human Factors Engineering	MIL-STD-1472 MIL-HDBK-46855
ID Markings	MIL-STD-130
Interface Shipboard Systems	MIL-STD-1399
Logistic Support Analysis	MIL-STD-1388
Logistics	MIL- HDBK-502 MIL-PRF-49506
Maintainability	MIL- HDBK-470 MIL-HDBK-791
Marking for Shipment & Storage	MIL-HDBK-129 MIL-STD-129
Microelectronics Test Methods	MIL-STD-883
Military Training Programs	MIL-HDBK-1379.1, .2, .3, .4 MIL-PRF-29612
Nondestructive inspection	MIL-HDBK-728 MIL-HDBK-731
Parts control	MIL-HDBK-965
Statement Of Work (SOW)	MIL-HDBK-245

ENGINEERING SPECIALTY TABLE

TECHNICAL DISCIPLINE	REFERENCE
Printed Wiring	IPC-D-275 IPC-2221
Producibility	MIL-HDBK-727
Quality (CANCELLED)	MIL-STD-9858
Quality Assurance Terms & Definitions	ISO 1804 ANSI 8402
Reliability Testing	MIL-HDBK-781
Reliability/durability	MIL- HDBK -1530 MIL- HDBK-87244 MIL- HDBK -1798 MIL- HDBK -2164
Review & Audits; Software	MIL-STD-1521B
Sampling Procedures	MIL-STD-105
Software	IEEE/EIA ISO 12207.0, .1, .2
Software (CANCELLED)	DOD-STD-2167 DOD-STD-2168
Software Support Environment	MIL-HDBK-1467
Standardization Program Requirements (CANCELLED)	MIL-STD-680
Supportability	MIL- HDBK-502
Survivability	MIL- HDBK -1799 MIL- HDBK -2069 MIL-HDBK-336
System Safety Engineering	MIL-STD-882
System Security	MIL- HDBK -1785
Tech Manuals; Data Base	MIL-PRF-87269
Technical Data Packages	MIL-DTL-31000A
Technical Manuals	MIL-STD-40051
Telecommunications	MIL-STD-188
Test Equipment (CANCELLED)	MIL-STD-1364
Test Reports	MIL-STD-831
Testability	MIL- HDBK -2165
Thermal design/analysis	MIL-HDBK-251
Timing & Sync	MIL-STD-188-115
Training requirements	MIL- HDBK-1379
Transportability	MIL-STD-1366
UHF MILSATCOM DAMA	MIL-STD-188-185
Vibrations	MIL-STD-167/2A
Weight & balance control	SAWE-RP7
Work Breakdown Structure	MIL-HDBK-881

Appendix H – Naval Process Flow Diagrams

The following are 33 summary charts of the Naval process. Elaboration and details (hyperlinks) are contained in the main document.

Sub-process 1: Product Supply

Preceding Process

Acquisition Process
Sub-process 2
Planning Process
Sub-process 8

Inputs

- Acquisition Strategy (SP 2)
- Solicitation (RFP/SOO/SOW) (SP 2)
- Acquirer Offer (SP 2)
- Requests for clarification (SP 2)
- RFI (SP 2)
- Acquirer Signed Agreement (SP 2)
- NAVAIR Specific:
  - TAA (SP 8)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents.

Purpose

Establish and satisfy an agreement with the acquirer.

Tasks

a) Assess the acquisition request, offer, or directive to determine the capability to meet the acquisition document requirements.
b) Establish a satisfactory agreement within legal, regulatory, enterprise, and project bounds.
c) Record the established agreement in the form appropriate to the effort.
d) Implement the processes of this Guide, as applicable, to meet the requirements of the agreement.
e) Deliver the products and other deliverables as specified in the established agreement.

Agents

Contracts
Systems Engineering
Logistics/R&M
Business Development
Acquirer
Manufacturing
Technical Writer
Legal
Security

Tools

Requirements Management & System Architecture Data Base
Make versus Buy
PRWeb

Next Process

Acquisition Process
Sub-process 2
Control Process
Sub-process 12
Implementation Process
Sub-process 20
System Verification Process
Sub-processes 31, 32
End Product Validation Process
Sub-process 33

Outputs

All outputs should be archived (SP 12)

- Supplier Proposal (SP 2)
- Supplier Signed Agreement (SP 2)
- End Products (SP 2, 3, 20, 31, 33)
- Enabling Products (SP 2, 3, 20, 31, 32, 33)

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents.

References

Standard References
OSD Commercial Item Acquisition: Considerations and Lessons Learned, 26 June 2000
MIL-STD-961, MIL-HDBK-245
SD-2 Buying Commercial and Non-Developmental Items: A Handbook
SD-5 Market Research
Managing Quality and Productivity in Aerospace and Defense, Nov 1989
NAVAIR Specific: NAVAIRINST 5400.154

Metrics and Measures

Timeliness
Technical performance requirements compliance
Controlling cost
Management Responsiveness
Program / Subcontract Management
Discrepancies (noted and/or unresolved)
Acceptance of test results

Sub-process 2: Product Acquisition

Preceding Process
Supply Process
    Sub-process 1
Acquisition Process
    Sub-process 3
Planning Process
    Sub-processes 5, 6, 7, 8
Requirements Definition Process
    Sub-process 14
Solution Definition Process
    Sub-process 19
End Products Validation Process
    Sub-process 33

Inputs
- Supplier Proposal (SP 1)
- Supplier Signed Agreement (contract or program directive) (SP 1)
- End Products (SP 1)
- Enabling Products (SP 1)
- Supplier Performance Management Plan (SP 3)
- WBS (SP 5)
- IMS (SP 6)
- TEMP (SP 7)
- SSP (SP 7)
- TWP (SP 8)
- SOO (SP 8)
- SOW (SP 8)
- ICD – formerly MNS (SP 14)
- CDD or CPD – formerly ORD (SP 14)
- Specified Requirements (SP 19)
- OTRR certification message (SP 33)
- Cost, Schedule, and Performance constraints (EXT)
- Acquisition Strategy (EXT)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents

Purpose
Establish an agreement with that supplier.

Tasks
a) Prepare the applicable acquisition request, offer, or directive to obtain supply of work or delivery of desired system products.
b) Evaluate supplier response to acquisition request, offer, or directive.
c) Make offer or provide directive to desired supplier.
d) Negotiate agreement to establish a satisfactory agreement within legal, regulatory, enterprise, and project bounds.
e) Record the established agreement in the form appropriate to the effort.
f) Accept delivered products.

Agents
Contracts
Source Selection
Legal
Program Manager (PM)
System Engineering
Logistics
T&E

Tools
Specifications
PRWeb
Proposal Evaluation Report
Turbo Streamliner
Turbo Specright!

Next Process
Supply Process
    Sub-process 1
Acquisition Process
    Sub-process 3
Planning Process
    Sub-process 5, 6, 8
Control Process
    Sub-process 12
Transition to Use Process
    Sub-process 21

Outputs
All outputs should be archived SP 12
- Cost, schedule, and performance constraints (SP 5, 8)
- Acquisition Strategy (SP 1, 5, 6)
- Solicitation (RFP, SOW or SOO with Cost/Schedule Requirements) (SP 1, 3, 5)
- Acquirer Offer (SP 1)
- Request for Clarification (SP 1)
- Request for Information (RFI) (SP 1)
- Acquirer Signed Agreement (contract or program directive) (SP 1, 3)
- ILS Certification (SP 21)
- Signed DD Form 250(s) (SP 21)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents

References
Standard References
MIL-STD-499B, MIL-HDBK-245, MIL-STD-961D
Managing Quality and Productivity in Aerospace and Defense, Nov 1989
OSD Commercial Item Acquisition: Considerations and Lessons Learned, 26 June 2000
SD-2 Buying Commercial and Non-Developmental Items: A Handbook
SD-5 Market Research
CMMI 2001
DD Forms 1423, 250, 254

Metrics and Measures
IPT Participation, Review and Concurrence
Technical Reviews
Product Metrics
Process Metrics
Measures of Effectiveness and Suitability
Measures of Performance
Technical Performance Measurements
Suitability Metrics
Product Affordability
Timing
Earned Value

Sub-process 3: Supplier Performance

Preceding Process

Supply Process
- Sub-process 1

Acquisition Process
- Sub-process 2

Assessment Process
- Sub-process 9, 10

Control Process
- Sub-process 13

Solution Definition Process
- Sub-process 19

Inputs
- Solicitation (RFP, SOW or SOO with Cost/Schedule Requirements) (SP 2)
- Specified Requirements (SP 19)
- Acquirer Signed Agreement (contract or program directive) (SP 2)
- Approved changes (SP 13)
- End Products (SP 1)
- Enabling Products (SP 1)
- Plans and schedules trend analysis (SP 9)
- Requirements trend analysis (SP 10)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents
- Sponsor/User Agreement
- Negotiated Agreement
- Validated Requirements

Purpose

Manage supplier performance (and sub-suppliers) to ensure that the technical effort to be accomplished by the supplier provides end products that satisfy the assigned requirements.

Tasks

a) Define the required developer-supplier relationships
b) Participate on appropriate supplier product teams.
c) Monitor supplier performance against key product metrics.
d) Flow-down changes in requirements or operational concept that might affect the supplier's project.
e) Control changes to requirements made by the supplier that would affect the developer's project or other related projects or products.
f) Assess supplier performance against assigned requirements including conduct of, or participation in, appropriate technical reviews.
g) Validate products delivered from the supplier, or ensure that products have been validated before delivery and prior to integration with other products that form a composite end product intended to meet the developer's specified requirements.

Agents

Acquirer/Developer
PEO/PM
User/Fleet
Logistics
Procurement
Systems Engineering

Tools

Requirements Management & System Architecture Data Base
Project Management Tools
Tools Survey: Requirements Management Tools

Next Process

Acquisition Process
- Sub-process 2

Control Process
- Sub-process 12

Outputs

All outputs should be archived SP 12
- Supplier Performance Management Plan (SP 2, 3)

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents.
- Key metrics have been met.
- Tech. reviews have been completed.
- Delivered Product satisfies requirements and approved changes.

References

Standard References
CMMI 2001

Metrics and Measures

Report supplier progress against Key Metrics
Report percentage of Flow Down requirements changes (CM)
Report on percentage of products delivered that have been validated

Sub-process 4: Process Implementation Strategy

Preceding Process
Requirements Definition Process
Sub-process 14

Inputs
- CDD or CPD – formerly ORD (SP 14)
- ICD – formerly MNS (SP 14)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents

Purpose
Define a strategy for implementing the adopted process of this Guide as a basis for project technical planning and that is in accordance with the agreement.

Tasks
a) Identify stakeholders who will have an interest or stake in the outcome of the project.
b) Identify and acquire applicable documents and the requirements therein, that could affect the project.
c) Identify process approaches required to develop enabling products (e.g., test, training, etc.).
d) Identify applicable enterprise-based life-cycle phases, expected work product outputs, applicable management reviews, and life-cycle-phase exit criteria.
e) Identify and define how the applicable processes of this Guide will be integrated, how internal and external projects will be involved, and how they will be integrated.
f) Identify and define progress assessment metrics and reporting requirements.
g) Prepare, document, and make available the process implementation strategy.

Agents
Systems Engineering
Program Manager
Logistics

Tools
Master Acquisition Planning Program (MAPP) v1.1

Next Process
Planning Process
Sub-process 5, 6, 7, 8
Control Process
Sub-process 12
Requirements Definition Process
Sub-process 15

Outputs
All outputs should be archived SP 12
- List of stakeholders and roles (SP 4, 15)
- Associated process approaches (SP 4)
- Life-cycle phase chart (Milestones) (SP 4, 6, 8)
- Work products and outputs (SP 4)
- Work product reviews (SP 4)
- Life-cycle phase exit criteria (SP 4, 8)
- List of applicable tasks (SP 4)
- Program metrics and reporting requirements (SP 4)
- Project Library (SP 5)
- Process Implementation Strategy (SP 5, 6, 7, 8)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agent. Planning team agrees to estimates and customers acknowledge receipt of information.

References
Standard References
CMMI 2001
NAVAIR Specific:
NAVAIR Acquisition Guide
NAVAIRINST 4200.36C, Acquisition Plans
Class Desk Orientation, March 2000

Metrics and Measures
Estimated cost of project
Estimated schedule of project
Estimated cost and time spent planning
Actual cost and time spent planning

Sub-process 5: Technical Effort Definition

Preceding Process
Acquisition Process
Sub-process 2
Planning Process
Sub-process 4, 6, 7
Requirements Definition Process
Sub-process 14, 15, 16

Next Process
Acquisition Process
Sub-process 2
Planning Process
Sub-process 6, 7, 8
Assessment Process
Sub-process 9, 10, 11
Control Process
Sub-process 12
Requirements Definition Process
Sub-process 16
Systems Analysis Process
Sub-process 22, 24
System Verification Process
Sub-process 32

Inputs
- Process Implementation Strategy (SP 4)
- Project Library (SP 4)
- Organizational Structure (SP 6)
- IMS (SP 6)
- Acquirer requirements (SP 14)
- MOEs (SP 14)
- Other stakeholder requirements (SP 15)
- System technical requirements (SP 16)
- Data and Document Management Plans (SP 7)
- Configuration Management Plans (SP 7)
- Acquisition Strategy (SP 2)
- Cost, schedule, and performance constraints (SP 2)
- Solicitation (RFP, SOW or SOO with Cost/Schedule Requirements) (SP 2)

NAVAIR Specific: POG (SP 6)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents.

Purpose
Define a technical effort that is in accordance with the process implementation strategy.

Tasks
a) Identify project tasks to include all requirements; and enterprise, project, and associated process constraints.
b) Establish an Enterprise Data Repository (including an information database).
c) Determine the risk management strategy.
d) Define product metrics and process metrics.
e) Establish cost objectives to be used in Trade-off analyses.
f) Identify technical performance measures that will receive management focus and be tracked using TPM procedures.
g) Identify applicable tasks.
h) Identify the appropriate methods and tools, required facilities and equipment, and training required.
i) Identify applicable or potential technology constraints and develop an approach for overcoming each constraint.

Agents
Acquirer
PEO/PM
End User
Systems Engineering
Technical Writer

Tools
WBS
EVMS

Outputs
All outputs should be archived SP 12
- TDP (SP 16)
- Enterprise Data Repository (SP 12)
- Risk Mngmnt Strategy (incl. Risk Advisory Board reqt(s) (SP 24)
- Program metrics (SP 9)
- Process metrics (SP 9)
- Product metrics (SP 10)
- Testing metrics (SP 11)
- CAIV decision criteria (SP 22)
- Total Life Cycle Cost Objectives (SP 6, 8)
- Tech Perf Measures (TPM) (SP 9, 10, 11, 22)
- WBS (with WBS Dictionary) (SP 2, 6, 7, 9, 10)
- Inputs to EVMS (SP 8, 9)
- Technology Roadmap (SP 16)
- List of: Methods and Tools, Facilities, Equipment, Training (SP 32)
- Life Cycle Support Plans (SP 16)
- Pre-Plan Prod. Improvement (P3I) (SP 16)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents.

References
Standard references
Top Eleven Ways to Manage Risk
CMMI General Information
Business Case Analysis Risk Assessment Matrix
Managing Quality and Productivity in Aerospace and Defense, Nov 1989
OSD Commercial Item Acquisition: Considerations and Lessons Learned, 26 Jun 2000
AVDEP-HDBK-7, Rev.1, 1 Feb 1996
EIA-748 EVMS, 1998
MIL-HDBK-881, 2 Jan 1998
ISO 9000 and ISO 14000
NAVAIR Specific:
Web addresses cited for DAU EVM Dept / EVMS Policy / EVM Implementation Guide
Draft NAVAIR Risk Management Guide

Metrics and Measures
Risk Cube
EVMS
WBS
Capability Maturity

Sub-process 6: Schedule and Organization

Preceding Process
Acquisition Process
Sub-process 2
Planning Process
Sub-process 4, 5
Requirements Definition Process
Sub-process 16

Inputs
- Acquisition strategy (SP 2)
- Total Life Cycle Cost Objective (SP 5)
- System Technical Requirements (SP 16)
- WBS (SP 5)
- Life Cycle Phase Chart (Milestones) (SP 4)
- Process Implementation Strategy (SP 4)

Entry Criteria
Inputs have been approved by the appropriate agent.
- Milestone approval
- Receipt of funding
- Request from Acquirer

Purpose
To schedule and organize the defined technical effort

Tasks
a) Develop an event-based schedule that integrates key events (internal and external), related tasks, specialty engineering tasks, and relevant completion criteria for the applicable enterprise-based life-cycle phase.
b) Develop the calendar-based schedule, showing the dates of expected task and event completions and the dependency relationships among tasks, with the goal of developing information for an Integrated Master Schedule (IMS).
c) Identify resources required to complete scheduled tasks.
d) Define the staffing and discipline needs to complete the scheduled tasks, training needs, and risks if required staff is not available.
e) Define the team and organizational structure to complete the scheduled tasks within resource constraints.

Agents
Acquirer
Systems Engineering
User
Specialty Engineering
Logistics

Tools
Scheduling tools
Estimating tools

Next Process
Acquisition Process
Sub-process 2
Planning Process
Sub-process 5, 7, 8
Assessment Process
Sub-process 9, 10, 11
Control Process
Sub-process 12
Transition to Use Process
Sub-process 21

Outputs
All outputs should be archived (SP 12)
- Resource requirements (staffing, cost) (SP 7)
- Organizational structure (SP 5, 7, 8)
- IMS (SP 2, 5, 7, 8, 9, 10, 11, 21)

NAVAIR Specific:
- Program Operating Guide (POG) (SP 5)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agent.
- All task and work allocated plus resources identified.
- Firm organizational structure

References
Standard References
DI-MISC-81183A Integrated Master Schedule Data Item Description (DID)
CMMI 2001

Metrics and Measures
Schedule variance (SV)
Cost variance (CV)
Staffing
Percent complete

Sub-process 7: Technical Plans

Preceding Process

Planning Process
Sub-process 4, 5, 6
Requirements Definition Process
Sub-process 14

Inputs

- ICD – formerly MNS (SP 14)
- CDD or DPD – formerly ORD (SP 14)
- MOEs (SP 14)
- Process Implementation Strategy (SP 4)
- WBS (SP 5)
- IMS (SP 6)
- Organizational Structure (SP 6)
- Resource Requirements (SP 6)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents.

- Key milestones established
- Technical effort and organization defined

Purpose

Create technical plans to ensure an integrated and cost effective technical effort in accordance with the defined schedule and organization.

Tasks

Prepare appropriate plans. Plans to consider include the following:

a) Engineering Plan
b) Risk Management Plan
c) Technical Review Plan
d) Verification Plans
e) Validation Plans
f) Other applicable plans as called for in the agreement or by enterprise policies and procedures

Agents

Acquirer
Systems Engineering
Program Manager
Test Engineers
COMOPTEVFOR
Contractors

Tools

Planning and scheduling tools
Automated Systems Engineering tools

References

Standard References
DI-MGMT-81024, Systems Engineering Management Plan (SEMP)
DI-NDTI-80566
DI-MISC-81180
CMMI 2001
EVMS
MIL- HDBK-512A, MIL-HDBK-61A
IEEE 1220
DI-CMAN-80858B
ISO/IEC 12207
ISO 9001
DAU: Risk Management Guide for DoD Acquisition
NAVAIR Specific:
NAVAIR INST 4130.1C
NAVAIR INST 5000.21
NAVAIR INST 4355.19B
APMSE Quick Reference Guide

Metrics and Measures

Plans completed and released on time

Next Process

Acquisition Process
Sub-process 2
Planning Process
Sub-process 5
Assessment Process
Sub-process 9, 10, 11
Control Process
Sub-process 12
Implementation Process
Sub-process 20
Systems Analysis Process
Sub-process 22, 24
Requirements Validation Process
Sub-process 25, 26, 27, 28, 29
System Verification Process
Sub-process 30, 31
End Product Validation Process
Sub-process 33

Outputs

All outputs should be archived (SP 12)

- SEP and/or SDP (SP 9, 10, 11, 22, 24, 30)
- TEMP (SP 2, 11, 30, 31, 33)
- Risk Management Plan (SP 24)
- CRLCMP (SP 9)
- Configuration Mngmnt Plan (SP 5, 9)
- QA Program Plan (SP 20)
- Manufacturing Plan (SP 20)
- Data and Document Mngmnt Plan (SP 5, 13)
- Security Mngmnt Plan (SP ALL)
- Verification Plan (incl. the Verification Compliance Req. Matrix (VCRM)) (SP 25, 30, 31)
- Validation Plan (to incl. what NAVAIR calls Op. Test Plan and Dvlpmnt Test Plan), known as OTTR Plan in SP 33 (SP 11, 25, 26, 27, 28, 29, 33)
- IV and V Plan (SP 30)
- SSP (SP 2)

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents.
All technical plans identified, written, and approved.

Sub-process 8: Work Directives

Preceding Process
Acquisition Process
Sub-process 2
Planning Process
Sub-process 4, 5, 6
Requirements Definition
Sub-process 16

Inputs
- Process Implementation Strategy (SP 4)
- Life Cycle Phase Chart (SP 4)
- Total Life Cycle Cost Objectives (SP 5)
- Life-cycle phase exit criteria (SP 4)
- Organizational Structure (SP 6)
- IMS (SP 6)
- Inputs to EVMS (SP 5)
- Cost, schedule, and performance constraints (SP 2)
- System Technical Requirements (SP 16)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents.

Purpose
Create work directives that implement the planned technical effort.

Tasks
a) Develop individual project team or organization work packages that describe the work to be done, resource sources, schedules, budget, and reporting requirements.
b) Generate work authorizations for the team or organization that provide approval for applicable teams or organizations to complete their work package requirements and to release applicable resources.

Agents
Acquirer, PEO/PM, IPT, Systems Engineering, Logistics

Tools
WBS
TAA Form

Next Process
Supply Process
Sub-process 1
Acquisition Process
Sub-process 2
Control Process
Sub-process 12
Requirements Definition Process
Sub-process 15
System Verification Process
Sub-process 30

Outputs
All outputs should be archived SP 12
- Team Work Plan (TWP) (SP 2, 15, 30)
- SOO (SP 2, 15, 30)
- SOW (SP 2, 15, 30)
- NAVAIR Specific:
  - TAA (SP 8)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents.
(TAA Signed, WBS defined)

References
Standard References
EVMS Industry Standards (EIA-748)
MIL-HDBK-881, MIL-STD-245D
NAVAIR Specific:
NAVAIRINST 5400.154

Metrics and Measures
Risk Cube
EVMS
WBS
Capability Maturity

Sub-process 9: Progress Against Plans and Schedules

Preceding Process

Planning Process
Sub-process 5, 6, 7
Systems Analysis Process
Sub-process 23

Inputs

- TPM (SP 5)
- WBS (SP 5)
- Inputs to EVMS (SP 5)
- Program metrics (SP 5)
- Process metrics (SP 5)
- IMS (SP 6)
- SEP or SPD (SP 7)
- CRLCMP (SP 7)
- Configuration Management Plan (SP 7)
- Trade-off Analysis Technical Report (SP 23)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents

Purpose

Assess the progress of the program effort against applicable plans, schedules, and budgets.

Tasks

a) List the appropriate events such as system specification, design reviews, tasks, and process metrics, including capability maturity, for monitoring progress against plans and schedules.
b) Collect and analyze identified process metrics data and results from completion of planned and scheduled tasks and events.
c) Compare process metrics data against plans and schedule using trend analysis to determine technical areas requiring management or team attention.
d) Determine risk and identify need to correct variances, make changes to plan and schedule, and redirect work because of risk.

Agents

Acquirer
Stakeholder
Program Management
Systems Engineering
Logistics
Cost

Tools

Rqmts Mgmt & Sys Arch Db
Schedule software w/Insight
Completion Date Histogram
Logic Diagrams
Gantt Bar Charts
Milestone Charts
Resource/Hour Usage Charts
Earliest, Expected and Latest Completion Dates and Durations

Next Process

Acquisition Process
Sub-process 3
Assessment Process
Sub-process 11
Control Process
Sub-process 12
Systems Analysis Process
Sub-process 23, 24

Outputs

All outputs should be archived SP 12

- List of appropriate events, tasks, and process metrics (SP 9)
- Process metrics data (SP 9)
- Program metrics data (SP 9)
- Plans and Schedule Trend Analysis (SP 3, 9, 11, 12, 23, 24)
- Cost Performance Report (CPR or C/SSR) (SP 12)

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents

References

Standard References
DAU Program Manager's Tool Kit

MIL-STD-499B Systems Engineering
EVMS
CMMI, 2001
NAVAIR Specific:
NAVAIR Acquisition Guide
NAVAIRINST 4355.19B

Metrics and Measures

Percent EVMS that is not level of effort
Accuracy of trend analysis
Amount of time between the closing of a reporting period and the reporting of a metric
Number of team members that have access to their appropriate metrics
IPT member satisfaction with the metrics
Provided EVMS metrics used

Sub-process 10: Progress Against Requirements

Preceding Process

Planning Process
    Sub-process 5, 6, 7
Assessment Process
    Sub-process 11
Requirements Definition Process
    Sub-process 14, 16
System Verification Process
    Requirements 30, 31

Inputs

- CDD – formerly ORD (SP 14)
- ICD – formerly MNS (SP 14)
- SEP or SDP (SP 7)
- TPM (SP 5)
- WBS (SP 5)
- Key Performance Parameters (SP 16)
- Product metrics (SP 5)
- IMS (SP 6)
- Technical Review Report (SP 11)
- Design Solution Deficiency & Discrepancy Reports (SP 30)
- End Product Deficiency & Discrepancy Reports (SP 31)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents

Purpose

Assess the progress of system development by comparing currently defined system characteristics against requirements.

Tasks

a) Identify product metrics, and their expected values, that will affect the quality of the product and provide information of the progress toward satisfying acquirer and other stakeholder requirements, as well as derived requirements.
b) Collect and analyze product metrics data.
c) Record rationale for decisions and assumptions made with respect to collected data.
d) Compare results against requirements to determine degree of technical requirement satisfaction, progress toward maturity of the system (or portion thereof) being engineered, and variations and variances from requirements.
e) Identify deficiencies and discrepanciesto specifications and configuration baselines.

Agents

Program Management
Systems Engineering
Logistics
Cost

Tools

Rqmts Mgmt & Sys Arch Db
Schedule software w/Insight

Next Process

Acquisition Process
    Sub-process 3
Assessment Process
    Sub-process 11
Control Process
    Sub-process 12
Solution Definition Process
    Sub-process 19
Systems Analysis Process
    Sub-process 23, 24

Outputs

All outputs should be archived SP 12

- Requirement trend analysis (SP 3, 11, 23, 24)
- Deficiencies and discrepancies (SP 11, 19)

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents

References

Standard References
DAU Program Manger's Tool Kit
DAU Program Manager's Tool Kit
MIL-STD-499B Systems Engineering
EVMS
CMMI 2001
NAVAIR Specific:
    NAVAIR Acquisition Guide
    NAVAIRINST 4355.19B

Metrics and Measures

Percent requirements (appropriate to the level of development) that have been analyzed, and percent deficiencies and discrepancies identified and reported to the appropriate agents.

Sub-process 11: Technical Reviews

Preceding Process
Planning Process
Sub-process 5, 6, 7
Assessment Process
Sub-process 9, 10, 11
Requirements Definition Process
Sub-process 14, 16
Solution Definition Process
Sub-process 19
System Verification Process
Sub-process 30, 31

Inputs
- CDD – formerly ORD (SP 14)
- ICD – formerly MNS (SP 14)
- Testing metrics (SP 5)
- TPM (SP 5)
- IMS (SP 6)
- Validation Plan (SP 7)
- SEP or SDP (SP 7)
- TEMP (SP 7)
- Plans and schedules trend analysis (SP 9)
- Requirement trend analysis (SP 10)
- Deficiencies and discrepancies (SP 10)
- System Requirements Document (SP 16)
- System technical requirements (SP 16)
- Specified requirements (SP 19)
- Design solution deficiency and discrepancy reports (SP 30)
- End product deficiency and discrepancy reports (SP 31)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents.

Purpose
Conduct technical reviews of progress and accomplishments in accordance with appropriate technical plans.

Tasks
a) Identify the review objectives and requirements cited in the Systems Engineering Plan (SEP); enterprise policies and procedures; and agreement, as applicable.
b) Verify completion of the technical review entry requirements.
c) Establish the technical review board, agenda, and speakers.
d) Prepare the appropriate materials to include in the read-ahead technical review package and presentation package.
e) Facilitate and support identification and resolution of emerging issues prior to the review.
f) Conduct the technical review using the guidance of the Design Review Handbook according to the SEP, identifying and documenting action items required to meet the review objectives.
g) Close out the review after (1) minutes have been prepared, approved, and distributed; (2) action items have been resolved; and (3) the review has been signed-off by the director.

Agents
Acquirer
Stakeholders
Program Management
Systems Engineering
Logistics

Tools
Rqmts Mgmt & Sys Arch Db

Next Process
Assessment Process
Sub-process 10
Control Process
Sub-process 12

Outputs
All outputs should be archived SP 12
- Technical Review Report (SP 10)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents

References
Standard References
MIL-STD-499B Systems Engineering
NAVSO P-6071 Best Practices Section 4.0
DoD 4245.7-M Transition from Development to Production Chapter 3
MIL-STD-1521
NAVAIR Specific:
NAVAIRINST 4355.19B
NAVAIR Design Review Handbook (AIR 4.1)

Metrics and Measures
Minutes and action items completed and accepted by the appropriate agent
Functional Allocation
Performance
Cost, Schedule, Weight
Risk

Sub-process 12: Outcomes Management

Preceding Process
All System Engineering Processes
Sub-process 1-11, 13-33

Inputs
The following is a generalized list, not all-inclusive, of information that should be included in the Enterprise Data Repository.

- Mission Areas (NMETL, MCPs, JTLs, etc.)
- Solicitations
- Proposals
- Signed agreements
- Program plans and Technical plans
- Changes
- Stakeholder information (e.g., DOTMLPF)
- Reference documents
- Policies, methods, and procedures
- Technical Data Packages
- Metrics
- Cost objectives/information
- WBS
- Schedules
- Life Cycle Support Plans
- POG's (NAVAIR unique)
- Analyses
- Reports
- Technical presentations
- Requirements
- Traceability matrix
- Trade studies
- Functional and physical baselines
- Certifications
- Specifications
- SEP
- Deficiencies and discrepancies

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents

Purpose
Manage the outcomes of the technical effort.

Tasks

a) Capture the outcomes, descriptions of methods and tools used, decisions and assumptions, lessons learned, and other data that allow for tracking requirements.
b) Perform configuration management.
c) Perform change management.
d) Perform interface management.
e) Perform risk management.
f) Perform data and document management.
g) Manage the information database.
h) Manage and track stakeholder requirements, system technical requirements, logical solution representations, physical solution representations, derived technical requirements, specified requirements, approved changes, and validation results.

Agents
PM
Systems Engineering

Tools
Rqmts Mgmt & Sys Arch Db

Next Process
Control Process
Sub-process 13

Outputs

- Program Information (SP 13)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents

References
Standard References

Metrics and Measures
Information is accurate and available in a timely manner as defined by the program.

Sub-process 13: Information Dissemination

Preceding Process
Information requests could come from any of the other 32 sub-processes

Purpose
Ensure that required and requested information is disseminated in accordance with the agreement, project plans, enterprise policies, and enterprise procedures.

Tasks

a) Provide technical progress status.
b) Provide technical planning information.
c) Disseminate approved and controlled requirements.
d) Provide information for, and from, technical reviews.
e) Make available design data and schema.
f) Make available lesson learned.
g) Report variances.
h) Disseminate data deliverables.
i) Disseminate approved changes.
j) Disseminate directives.

Next Process
Sub-process(es) corresponding to the requested infomation

Inputs
- Program Information (SP 12)
- Requests for information (SP All)

Outputs
All outputs should be archived SP 12
- Program information (SP requesting sub-process) (SP ALL)
- Completed request for information forms (SP 12)
- Status of Information dissemination (SP 12)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents.

Agents
Information Specialist
Data and Document Manager
Systems Engineering
Acquirer
Supplier

Tools
Microsoft Word
Excel Spreadsheet
Enterprise Data Repository

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents.

References
Standard References
Security control directives for the handling, packaging and transmittal of classified information
CMMI 2001

Metrics and Measures
Percent of on-time deliveries of information requested.
Percent of on-time deliveries of information required.
Number of complaints on the quality of disseminated information.
Number of security violations for improper handling, storage, and transmittal of classified materials.

Sub-process 14: Acquirer Requirements

Preceding Process
Systems Analysis Process
Sub-process 22
Requirements Validation Process
Sub-process 26

Inputs
- ICD – formerly MNS (User, Fleet) (EXT)
- CDD – formerly ORD (OPNAV) (EXT)
- Engineering Investigation Reports (User, Fleet) (EXT)
- Utilization and Readiness Reports (NALCOMIS) (EXT)
- Specifications from higher level system building blocks (EXT)
- Sponsor High-Level Operational. Concept Graphic (OV-1) arch. (EXT)
- Effectiveness Analysis reports (SP 22)
- Effectiveness Models (SP 22)
- Acquirer Requirements Validation Revisions (SP 26)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents

Purpose
Define a validated set of acquirer requirements for the system, or portion thereof.

Tasks
a) Identify, collect, and prioritize assigned, customer, user, or operator requirements for the system, or portion thereof, including any requirements for development, production, test, deployment/installation, training, operations, support/maintenance, and disposal of the system's products.
b) Ensure that the resulting set of requirements agrees with the acquirer needs and expectations
c) Record the resulting set of acquirer requirements in the established information database.

Agents
Acquirer and User
Concepts Analysis
Cost Analysis
Fleet Project Team (FPT)
Ops Analysis
R&M
Systems Engineering

Tools
Survey
Questionnaire
QFD Capture
M&S
Queuing Methodology
IDEF
Rqmts Mgmt & Sys Arch Db

Next Process
Acquisition Process
Sub-process 2
Planning Process
Sub-process 4, 5, 7
Assessment Process
Sub-process 10, 11
Control Process
Sub-process 12
Requirements Definition Process
Sub-process 16
Systems Analysis Process
Sub-process 22
Requirements Validation Process
Sub-process 26
System Verification Process
Sub-process 31
End Products Validation Process
Sub-process 33

Outputs
All outputs should be archived SP 12
- ICD – formerly MNS (SP 2, 4, 7, 10, 11, 16, 31, 33)
- Effectiveness Analysis Request (SP 22)
- MOE (SP 5, 7, 16)
- CDD or CPD – formerly ORD (SP 2, 4, 7, 10, 11, 16, 31, 33)
- Specifications from higher level system building blocks (SP 16)
- Acquirer Requirements (SP 5, 16, 26)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents

References
Standard References
Systems Engineering & Analysis (Blanchard)
MIL-STD-498
CMMI 2001

Metrics and Measures
Percent completion of analysis and output products.
Percent of acquirer requirements that have been validated.

Sub-process 15: Other Stakeholder Requirements

Preceding Process
Planning Process
Sub-process 4, 8
Systems Analysis Process
Sub-process 22
Requirements Validation Process
Sub-process 27

Inputs
- List of stakeholders and roles (SP 4)
- TWP (SP 8)
- SOO (SP 8)
- SOW (SP 8)
- Effectiveness Analysis Reports (SP 22)
- Effectiveness Models (SP 22)
- Other stakeholder requirements validation revisions (SP 27)
- DoD/Naval policy and directives (EXT)
- Federal/International Laws and regulation (EXT)
- International/ National standards (EXT)
- Team / Project objectives, constraints, and policy (EXT)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents

Purpose
Define a validated set of other stakeholder requirements for the system, or portion thereof.

Tasks
a) Identify and collect other stakeholder requirements that can constrain the system's end products.
b) Identify and collect other stakeholder requirements that can constrain development, production, test, deployment/installation, training, support/maintenance, and disposal of the system products.
c) Identify and collect other stakeholder constraints such as applicable laws and regulations; technology base; standards and specifications; competitor's product capabilities and trends; and interfaces with other evolving systems or platforms.
d) Ensure that the resulting set of requirements agrees with other stakeholder needs and expectations
e) Record the resulting set of stakeholder requirements in the established information database.

Agents
Systems Engineering
Enterprise Management
PM, PEO
Logistics, Manufacturing
Depot
T&E
Other Syscoms

Tools
Surveys
Questionnaire
Rqmts Mgmt & Sys Arch Db

Next Process
Planning Process
Sub-process 5
Control Process
Sub-process 12
Requirements Definition Process
Sub-process 16
Systems Analysis Process
Sub-process 22
Requirements Validation Process
Sub-process 27

Outputs
All outputs should be archived SP 12
- Effectiveness Analysis Request (SP 22)
- Other stakeholder requirements (SP 5, 16, 27)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents

References
Standard References
IPPD Handbook

Metrics and Measures
Percent completion of analysis and output products.
Percent of other stakeholder requirements that have been validated.

Preceding Process
Planning Process
Sub-process 5
Requirements Definition Process
Sub-process 14, 15
Systems Analysis Process
Sub-process 22, 23
Requirements Validation Process
Sub-process 25, 28

Sub-process 16: System Technical Requirements

Next Process
Planning Process
Sub-process 5, 6, 8
Assessment Process
Sub-process 10, 11
Control Process
Sub-process 12
Solution Definition Process
Sub-process 17, 18
Systems Analysis Process
Sub-process 22, 23
Requirements Validation Process
Sub-process 25, 28
System Verification Process
Sub-process 30

Inputs
- Specifications from higher level system building blocks (SP 14)
- ICD – formerly MNS (SP 14)
- CDD – formerly ORD (SP 14)
- Sponsor High-Level Operational. Concept Graphic (OV-1) arch. (EXT)
- MOE (SP 14)
- Acquirer requirements (SP 14)
- Other stakeholder requirements (SP 15)
- Effectiveness Analysis Report (SP 22)
- Effectiveness Models (SP 22)
- Trade-off Analysis Technical Report (SP 23)
- Requirement statements validation revisions (SP 25)
- System technical requirements validation revisions (SP 28)
- TDP (SP 5)
- Technology Roadmap (SP 5)
- Life Cycle Support Plans (SP 5)
- P3I (SP 5)

Purpose
Define a validated set of system technical requirements.

Tasks
a) Establish required transformation rules, priorities, inputs, outputs, states, modes, and configurations
b) Define operational requirements.
c) Define performance requirements.
d) Analyze acquirer and other stakeholder requirements, and derived functional and performance requirements.
e) Identify and resolve requirements that have questionable utility or have unacceptable risk of not being satisfied.
f) Resolve identified conflicts between the requirements.
g) Prepare a set of system technical requirement statements that are well formulated.
h) Ensure that the set of system technical requirements is correct.
i) Record the resulting set of system technical requirements in the established information database.

Agents
Logistics
Ops Analysis
Systems Engineering
Test
Specialty Engineering
User

Tools
FFBD
QFD
Context Diagram
Timeline Analysis

Outputs
All outputs should be archived SP 12
- Utilization environment (SP 16)
- Verification approach (SP 16)
- Operational Profiles (SP 16, 17)
- Physical and functional requirements (SP 16, 17)
- Mission Profiles (SP 16, 17)
- Cycle timelines (SP 16, 17)
- MOP (SP 16, 17)
- KPP (SP 10, 16, 17)
- Functional performance (SP 16, 17)
- Human interface requirements (SP 16, 17)
- Function concurrency / capacity (SP 16, 17)
- Technology constraints (SP 16, 18)
- Design constraints (SP 16, 18)
- Enabling products requirements (SP 16, 17)
- Conflicting requirements (SP 16, 17)
- Effectiveness Analysis Request (SP 22)
- Trade Options and Constraints (SP 23)
- System Requirements Document (SRD) (SP 11, 17)
- System Technical Requirements (SP 5, 6, 8, 11, 17, 25, 28, 30)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents

References
Standard References
IEEE 1220
MIL-STD 499B
System/Subsystem Specification (SSS) Data Item Description (DI-IPSC-81431)
World Class Example, Jerry Lake, 1999.

Metrics and Measures
Percent completion of analysis and output products
Percent of system technical requirements that have been validated

Sub-process 17: Logical Solution Representations (Functional Analysis)

Preceding Process

Requirements Definition Process
  Sub-process 16
Systems Analysis Process
  Sub-process 22, 23
Requirements Validation Process
Sub-process 25
  Sub-process 29

Next Process

Control Process
  Sub-process 12
Solution Definition Process
  Sub-process 18
Systems Analysis Process
  Sub-process 22, 23
Requirements Validation Process
  Sub-process 25, 29

Inputs

- System Technical Requirements (SP 16)
- Operational Profiles (SP 16)
- Physical and functional requirements (SP 16)
- Mission Profiles (SP 16)
- Cycle timelines (SP 16)
- MOP (SP 16)
- KPP (SP 16)
- Functional performance (SP 16)
- Human interface requirements (SP 16)
- Function concurrency / capacity (SP 16)
- Enabling products requirements (SP 16)
- Conflicting requirements (SP 16)
- SRD (SP 16)
- Effectiveness Analysis Report (SP 22)
- Effectiveness Models (SP 22)
- Trade-off Analysis Technical Report (SP 23)
- Requirement statements validation revisions (SP 25)
- Logical solution representation validation revisions (SP 29)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents

Purpose

Define one or more validated sets of logical solution representations that conform with the technical requirements of the system.

Tasks

a) Select and implement one or more appropriate approaches to providing an abstract definition of the solution to the system technical requirements.
b) Establish sets of logical solution representations
c) Assign (i.e., perform Requirements Allocation of) system technical requirements to elements of the logical solution representations.
d) Identify and define derived technical requirement statements resulting from tasks a) and b).
e) Ensure that each set of logical solution representations is correct.
f) Record the resulting sets of logical solution representations, the set of derived technical requirement statements, and any unassigned system technical requirements, along with source rationale and assumptions in the established information database.

Agents

Systems Engineering
R&M
Human Systems Integration
Safety
Design
Logistics
Test
Software Development

Tools

Rqmts Mgmt & Sys Arch Db

Outputs

All outputs should be archived SP12

- Functional Analysis Products (SP 18) (FFBD / Functional Decomposition, Timeline)
- Structured Analysis Products (SP 18) (Context / QFD / Data Dictionaries / Entity-Relationship / M&S Diagrams)
- Object Oriented Analysis Products (SP 18) (Classical / Behavior / Domain / Use Case Analyses)
- N2 / FMEA / FMECA / RAS (SP 18)
- Effectiveness Analysis Request (SP 22)
- Trade options and constraints (SP 23)
- Derived Technical Requirements (SP 25)
- Logical Solution Representation (SP 18, 29)

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents

References

Standard References
Systems Engineering Analysis (Blanchard)
Standard Practice for Performing FMECA (MIL-STD-1629), DI-ILSS-81163A, DI-GDRO-81222
Object Oriented Analysis & Design (Booch)
Modern Structured Analysis (Yourdon)

Metrics and Measures

Percent Completion of Logical Solution Products
Percent of Logical Solution Products that have been validated.

Sub-process 18: Physical Solution Representation (Synthesis)

Preceding Process

Requirements Definition Process
Sub-process 16
Solution Definition Process
Sub-process 17
Systems Analysis Process
Sub-process 22, 23, 24
Requirements Validation Process
Sub-process 25

Inputs

- Design constraints (SP 16)
- Technology constraints (SP 16)
- Functional Analysis Products (SP 17) (FFBD / Functional Decomposition, Timeline)
- Structured Analysis Products (SP 17) (Context /QFD / Data Dictionaries / Entity-Relationship / M&S Diagrams)
- Object Oriented Analysis Products (SP 17) (Classical / Behavior / Domain / Use Case Analyses)
- N2 / FMEA / FMECA / RAS (SP 17)
- Logical Solution Representation (SP 17)
- Effectiveness Analysis Report (SP 22)
- Effectiveness Models (SP 22)
- Trade-off Analysis Technical Report (SP 23)
- Risk Analysis Report (SP 24)
- Requirement statements validation revisions (SP 25)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents

Purpose

Define a preferred set of physical solution representations that agrees with the assigned logical solution representations, derived technical requirements, and system technical requirements.

Tasks

a) Analyze logical solution representations, derived technical requirements, and any unassigned system technical requirements.
b) Assign representations from Sub-process 17, unassigned system technical requirements, and derived technical requirements to physical entities that will make up a physical solution.
c) Generate alternative physical solutions by:
   1) Identification and definition of physical interfaces
   2) Identification and analysis of critical parameters
   3) Identification and assessment of physical solution options
   4) Performance of system analysis
d) Identify and define derived technical requirement statements resulting from tasks a), b), and c) that are stated acceptably in accordance with Sub-process 25.
e) Select the preferred physical solution representation for further characterization into a design solution.
f) Ensure that the selected physical solution representation is consistent.
g) Record the selected physical solution representation.

Agents

Systems Engineering
R&M
Human Systems Integration
Safety
Security
Design, Logistics, Test, Producibility, Software Design

Tools

Rqmts Mgmt & Sys Arch Db
SBD
N2 Diagrams
RAS
Concept DescriptionSheets
Design Sheets

Next Process

Control Process
Sub-process 12
Solution Definition Process
Sub-process 19
Systems Analysis Process
Sub-process 22, 23, 24
Requirements Validation Process
Sub-process 25
System Verification Process
Sub-process 30

Outputs

All outputs should be archived SP 12

- Effectiveness Analysis Request (SP 22)
- Trade options and constraints (SP 23)
- Risk Analysis Request (SP 24)
- Physical Solution Options (SP 18)
- Derived Technical Requirements (SP 25)
- Selected physical solution representation (SP 19, 30)

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents

References

Standard References
Systems Engineering Analysis (Blanchard)
Standard Practice for Performing FMECA (MIL-STD-1629)

Metrics and Measures

Percent Completion of Physical Solution Products
Percent of Physical Solution Products that have been validated.

Preceding Process
Assessment Process
Sub-process 10
Solution Definition Process
Sub-process 18
Requirements Validation Process
Sub-process 25
System Verification Process
Sub-process 30, 31
End Products Validation Process
Sub-process 33

Sub-process 19: Specified Requirements (Document the Design Solution)

Next Process
Acquisition Process
Sub-process 2, 3
Assessment Process
Sub-process 11
Control Process
Sub-process 12
Implementation Process
Sub-process 20
Transition to Use Process
Sub-process 21
Requirements Validation Process
Sub-process 25
System Verification Process
Sub-process 30, 31, 32

Purpose
Specify requirements for the design solution.

Tasks
a) Fully characterize the design solution.
b) Ensure that the design solution is consistent with its source requirements.
c) Specify requirements for the system, system end products, and subsystems of each end product, as applicable to the engineering life-cycle phase.
d) Record the design solution work products in the established information database.
e) Establish projects to develop enabling products and to procure those that are off-the-shelf or will be reused.

Inputs
- Deficiencies and discrepancies (SP 10)
- Selected physical solution representation (SP 18)
- Requirement statements validation revisions (SP 25)
- Design solution deficiency and discrepancy reports (SP 30)
- End Product deficiency and discrepancy reports (SP 31)
- OT/FOT&E Report (SP 33)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents

Agents
Systems Engineering
R&M
Human Systems Integration
Safety
Design
Logistics
Test
Software Development

Tools
Rqmts Mgmt & Sys Arch Db
RAS
Specification Standards

Outputs
All outputs should be archived SP 12
- Specified Requirements (SP 2, 3, 11, 20, 21, 25, 30, 31, 32)
- Specified Requirements Products (SP 19)
- Enabling products development projects (SP 32)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents

References
Standard References
Systems Engineering Analysis (Blanchard)
Standard Practice for Defense Specifications (MIL-STD-100G)

Data Item Descriptions:
System / Subsystem Specification (SSS) (DI-IPSC-81431)
Interface Requirements Specification (IRS) (DI-IPSC-81434)
System Architecture Design (SSDD) (DI-IPSC-81432)

Data Item Descriptions, continued:
Software Requirements Specification (SRS) (DI-IPSC-81433)
Software Design Description (SDD) (DI-IPSC-81435)
Database Design Description (DBDD) (DI-IPSC-81437)
Interface Design Description (IDD) (DI-IPSC-81436)
Software Product Specification (SPS) (DI-IPSC-81441)
User Software Version Description (SVD) (DI-IPSC-81442)

Metrics and Measures
Percent Completion of Specified Requirements Products
Percent of Specified Requirements Products that have been validated.

Preceding Process
Supply Process
  Sub-process 1
Planning Process
  Sub-process 7
Solution Definition Process
  Sub-process 19
End Products Validation Process
  Sub-process 33

Sub-process 20: Implementation

Next Process
Control Process
  Sub-process 12
Transition To Use Process
  Sub-process 21

Inputs

- End Products (SP 1)
- Enabling Products (SP 1)
- Manufacturing Plans (SP 7)
- QA Program Plans (SP 7)
- Specified Requirements (SP 19)
- OT/FOT&E Report (SP 33)

Purpose

Implement (build/assemble/code/test) the design (preliminary or final) in accordance with the specified requirements to obtain a verified end product.

Tasks

a) Receive from suppliers, reuse from off-the-shelf supply, or receive from the acquirer the subsystem products that make up the system's end products, or, as appropriate, code or build the end products.
b) Validate the subsystem products received or reused against their acquirer requirements.
c) Assemble the validated subsystem products, or physically integrate such products into the respective test article or end product to be verified.
d) Verify each test article or end product against its specified requirements.
e) Ensure that the enabling products for each associated process will be ready and available to perform their intended support functions required by the system's end products.
f) Validate the verified end products against their acquirer requirements.

Outputs

All outputs should be archived SP 12

- Assembled End Product(s) or Enabling Product(s) (SP 20)
- Manufacturing Process & Personnel System (SP 21)
- Verified & Validated Integrated End Product or Enabling Product Report (SP 21)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents

Agents

Prime Contractor & Suppliers, Program Management, Systems Engineering, Mfg, QA, Logistics, Testing, Financial Management, Procurement, Parts Management, End User, DCMA

Tools

Design tools
Databases
Manufacturing Tooling
TPM Tracking tools/Schedules
Test Equipment/Requirements/Analysis
Statistical Process Control
Inspections/Reviews

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents

References

Standard References
FAR Parts 46 and 52.246
DFAR Part 46
ISO 9001
MIL-STD-1528A
MIL-STD-1521B
DoD-STD-2168
DoD-STD-2167A
Defense Manufacturing Guide
Technical Reviews
Manufacturing Management Program

Metrics and Measures

Adherence to Schedule and Progress Versus Plan
Requirement Execution Time and Cost
System Definition Detail
Technical Performance Measurement Resolution

- Availability
- Reliability
- Capability
- Effectiveness

Process Control Matrices

Preceding Process
Acquisition Process
Sub-process 2
Planning Process
Sub-process 6
Solution Definition Process
Sub-process 19
Implementation Process
Sub-process 20
System Verification Process
Sub-process 32

Sub-process 21: Transition to Use

Next Process
Control Process
Sub-process 12

Purpose
Transition verified products to the acquirer of the products in accordance with the agreement.

Tasks

a) Acquire and put in place appropriate enabling products to carry out relevant transition to use requirements.
b) Prepare end products for shipping and storage.
c) Store end products awaiting shipping, and ship or transport to the acquirer the intended usage sites.
d) Prepare sites where end products will be stored, installed, used or maintained, or serviced.
e) Install end products at the appropriate sites.
f) Perform commissioning to bring delivered or installed end products to operational readiness with appropriate acceptance and certification tests completed.
g) Provide a parallel operation (ghosting) of the new and the legacy end products so that service is continuous during the transition period.
h) Provide training for users, maintenance, and other personnel.
i) Provide in-service support
j) Deliver all planned support elements.

Inputs

- Verified and Validated Integrated End Product or Enabling Product Report (SP 20)
- Manufacturing Process & Personnel System (SP 20)
- IMS (SP 6)
- Specified Requirements (SP 19)
- Enabling Product Readiness determination (SP 32)
- ILS Certification (SP 2)
- Signed DD Form 250 (SP 2)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents

Outputs
All outputs should be archived SP 12

- Operational system products (EXT)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents

Agents
Logistics
FST
In-Service Support
PM

Tools
Not Applicable

References
Standard References

Metrics and Measures
Percentage of damaged products
On-time delivery

Sub-process 22: Effectiveness Analysis

Preceding Process
Planning Process
Sub-process 5, 7
Requirements Definition Process
Sub-process 14, 15, 16
Solution Definition Process
Sub-process 17, 18
Systems Analysis Process
Sub-process 23

Inputs
- TPM (SP 5)
- CAIV decision criteria (SP 5)
- SEP or SDP (SP 7)
- Effectiveness Analysis Request (SP 14, 15, 16, 17, 18, 23)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents

Purpose
Perform effectiveness analyses to provide a quantitative basis for decision-making.

Tasks
a) Plan effectiveness analyses to include purpose, opjectives, execution and data collection, schedule of tasks, resource need and availability, and expected outcomes.
b) Analyze each alternative for system and cost effectiveness.
c) Analyze each alternative for total ownership cost to the enterprise and to the acquirer.
d) Analyze the environmental impact of each alternative.
e) Analyze each alternative for each required operational profile to provide an analytical confirmation that the alternative satisfies appropriate requirements.
f) Record effective analysis outcomes in the established enterprise data repository.

Agents
Systems Engineering
Legal

Tools
Functional, physical, and analytic models
Simulation models
Virtual reality models
Mathematical models

Next Process
Control Process
Sub-process 12
Requirements Definition Process
Sub-process 14, 15, 16
Solution Definition Process
Sub-process 17, 18
Systems Analysis Process
Sub-process 23, 24

Outputs
All outputs should be archived SP 12
- Effectiveness Analysis Report (SP 14, 15, 16, 17, 18, 23, 24)
- Effectiveness Models (SP 14, 15, 16, 17, 18, 23)
- Effectiveness Analysis Plan (SP 22)
- Production Engineering Assessment (SP 22)
- Test & Evaluation Assessment (SP 22)
- Deployment & Installation Assessment (SP 22)
- Operations Assessment (SP 22)
- Support Assessment (SP 22)
- Training Assessment (SP 22)
- Total Ownership Cost Assessment (SP 22)
- Environmental Assessment (SP 22)
- Disposal Assessment (SP 22)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents

References
Standard References
Engineering Complex Systems with Models and Objects, Oliver, et al, 1997
MIL-STD-499B
Models and Simulations, DSMC, Sept 1994
Systems Engineering Management, Lacy, 1992
Systems Engineering Guidebook, Martin, 1996
System Engineering Planning & Enterprise Identity, Grady, 1994
Virtual Prototyping, DSMC, 1993

Metrics and Measures
Technical Performance Measurement (TPM), MOE
Capability, dependability, suitability, and cost effectiveness
Costs (Unit, system, procurement, acquisition, life cycle, total ownership)
CER

Sub-process 23: Trade-off Analysis

Preceding Process

Assessment Process
Sub-process 9, 10
Requirements Definition Process
Sub-process 16
Solution Definition Process
Sub-process 17, 18
Systems Analysis Process
Sub-process 22, 24

Inputs

- Trade Options and Constraints (SP 16, 17, 18)
- Plans and schedules trend analysis (SP 9)
- Requirements trend analysis (SP 10)
- Effectiveness Analysis Report (SP 22)
- Effectiveness Models (SP 22)
- Risk Analysis Report (SP 24)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents

Trade-off problem definition is complete

Purpose

Perform Trade-off analyses to provide decision-makers (i.e., Program Managers and Engineers) with recommendations, predictions of the results of alternative decisions, and other appropriate information to allow selection of the best course of action.

Tasks

a) Plan Trade-off analyses and develop a Trade-off Plan of Action and Milestones (POA&M).
b) Perform the Trade-off analysis according to the POA&M, and Produce a Trade-off Analysis Document and Trade-off Study Brief.
c) Record the outcomes of the Trade-off analysis in the enterprise data repository, including assumptions, details of the analysis, lessons learned, models used, rationale for decisions made, recommendations and effects, and other pertinent information affecting the interpretation of the decision made.

Agents

Program Management
System Engineering
Analysis

Tools

Analysis:
- Excel with VBA
- Visual Basic, C
- Access
- Warfare & System/ Subsystem Model
- Integrated Architecture Products

Planning/Documentation:
- Project
- Schedule
- Word
- PowerPoint

Next Process

Assessment Process
Sub-process 9
Control Process
Sub-process 12
Requirements Definition Process
Sub-process 16
Solution Definition Process
Sub-process 17, 18
Systems Analysis Process
Sub-process 22, 24

Outputs

All outputs should be archived SP 12
- Trade-off Analysis POA&M (SP 23)
- Effectiveness Analysis Request (SP 22)
- Risk Analysis Request (SP 24)
- Trade-off Analysis Technical Report (SP 9, 16, 17, 18)
- Trade-off Analysis Brief (EXT)

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents

Trade-off study is completei

Results are archived

References

Standard References
Naval Operations Analysis, Wagner, et al, 1999
Simulation and Modeling Analysis, Law and Kelton, 1981& 1982
System Engineering Management, Lacy, 1992
AIR 4.10 Warfare Analysis Department 'Analysis of Alternatives' Process
AIR 4.10 Warfare Analysis Department 'Warfare Analysis' Process
AIR 4.10 Warfare Analysis Department 'Source Selection Process' Process

Metrics and Measures

Trade-off study completion and acceptance by the appropriate agent
Adherence to schedule
Adherence to funding plan

Sub-process 24: Risk Analysis

Preceding Process

Planning Process
 Sub-process 5, 7
Assessment Process
 Sub-process 9, 10
Solution Definition Process
 Sub-process 18
Systems Analysis Process
 Sub-process 22, 23

Inputs

- Risk Management Strategy (SP 5)
- Risk Management Plan (SP 7)
- SEP or SDP (SP 7)
- Plans and schedules trend analysis (SP 9)
- Requirements trend analysis (SP 10)
- Risk Analysis Request (SP 18, 23)
- Effectiveness Analysis Report (SP 22)

Entry Criteria

Inputs have been reviewed and approved by the appropriate agents

Purpose

Perform risk analyses to develop risk management strategies, support management of risk, and support decision-making.

Tasks

a) Identification of technical risk, and resulting project risk, based on exposure to the probability of an undesireable consequence and the effect of that consequence for each Trade-off analysis option for each physical solution representation.

b) Characterize risks by causes, possible effects or consequences, likelihood of occurrence, options for dealing with risks, how long option is available, and coupling with other risks.

c) Prioritize risks that would likely cause harm, have the greatest effect on the system, and would require attention in the near term.

d) Evaluate ways to avert risk, and determine the cost, schedule, and performance effects on the project.

e) Define and implement a plan or approach for averting each significant risk.

f) Record the risk analysis outcomes in the enterprise data repository and communicate or use risk findings and impacts.

Agents

Typically a program Risk Management Board that is comprised of Program Management (1.0) and Systems Engineering

Tools

Program Risk Summaries
 (“Rubic’s cubes”)
DSMC “Weighted Factors”
Schedule Network Models
R&M Models
TPM Tracking tools
Integrated Architecture Products

Next Process

Control Process
 Sub-process 12
Solution Definition Process
 Sub-process 18
Systems Analysis Process
 Sub-process 23

Outputs

All outputs should be archived SP 12

- Risk Analysis Report (SP 18, 23)
- List of risks (SP 24)
- Analyses of Risk Severity (SP 24)
- Risk Summary Worksheet (SP 24)
- Waterfall Charts (SP 24)

Exit Criteria

Outputs have been reviewed and approved by the appropriate agents.

References

Standard References
DAU Prog. Mgr’s Tool Kit
NAVAIRINST 5000.21
NAVSO P-3686
CMMI 2001
MIL-STD-882

Metrics and Measures

Qualitative Risk Severity
Quantitative Risk Factor
Analog of Nichols Gowth Curve (keeping up with mitigation plan)

- Availability
- Reliability
- Capability

Sub-process 25: Requirements Statements Validation

Preceding Process
Planning Process
Sub-process 7
Requirements Definition Process
Sub-process 16
Solution Definition Process
Sub-process 17, 18, 19

Inputs
- Verification Plan (including verification matrix) (SP 7)
- Validation Plan (SP 7)
- System Technical Requirements (SP 16)
- Derived Technical Requirements (SP 17, 18)
- Specified Requirements (SP 19)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents

Purpose
Ensure that technical requirement statements and specified requirement statements, individually and as sets, are well formulated. This is validation of the language of the statements rather than the content.

Tasks
a) Analyze each requirement statement from Sub-processes 16, 17, 18, and 19 to ensure 1) ability to preserve competitiveness, 2) clarity, 3) correctness, 4) feasibility, 5) focus, 6) implementability, 7) modifiability, 8) removal of ambiguity, 9) singularity, 10) testability, 11) verifiability, and 12) performance based language (where appropriate).
b) Analyze requirement statements from Sub-processes 16, 17, 18, and 19 in pairs and sets to ensure 1) absence of redundancy, 2) connectivity, and 3) removal of conflicts.
c) Record requirement statements validation outcomes in the established enterprise data repository.

Agents
Systems Engineering
Technical Writer

Tools
Rqmts Mgmt & Sys Arch Db

Next Process
Control Process
Sub-process 12
Requirements Definition Process
Sub-process 16
Solution Definition Process
Sub-process 17, 18, 19

Outputs
All outputs should be archived SP 12
- Requirement statement validation revisions (SP 16, 17, 18, 19)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents

(Acceptable sets of requirements statements)

References
Standard References
MIL-STD-961D
SD-24: General Specification Performance, Design, Characteristics, and Construction of Aircraft Weapons Systems
Joint Services Specification Guides (JSSG)

Metrics and Measures
Percentage of validated requirements statements
Percentage of requirement statements issues

Sub-process 26: Acquirer Requirements Validation

Preceding Process
Planning Process
Sub-process 7
Requirements Definition Process
Sub-process 14

Inputs
- Validation Plan (SP 7)
- Acquirer Requirements (SP 14)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents

Purpose
Ensure that the set of defined acquirer requirements agrees with acquirer needs and expectations.

Tasks
a) Select the methods and define the procedures for validating that the set of acquirer requirements from Sub-process 14 is consistent with the level of system structure, enterprise-based life-cycle phase, and Validation Plan, as appropriate.
b) Analyze and compare the identified, derived and collected acquirer requirements to the set of defined acquirer requirements, to determine downward traceability.
c) Analyze and compare the set of defined acquirer requirements to the identified, derived, and collected acquirer requirements, to determine upward traceability.
d) Identify and resolve variances, voids, and conflicts (orphans).
e) Record validation results in the enterprise data repository.

Agents
Systems Engineering
Design Team
R&M
Safety
Supportability/Testability

Tools
Requirements Traceability Matrix Format
Rqmts Mgmt & Sys Arch Db

Next Process
Control Process
Sub-process 12
Requirements Definition Process
Sub-process 14

Outputs
All outputs should be archived SP 12
- Validation methods & procedures (SP 26)
- Requirements traceability matrix (SP 26)
- Acquirer requirements validation revisions (SP 14)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents

References
Standard References

Metrics and Measures
Percent of Acquirer Requirements downward traceable
Percent of Acquirer Requirements upward traceable
Percent of assumptions for Acquirer Requirements reviewed and approved
Percent of changed Acquirer Requirements revalidated

Sub-process 27: Other Stakeholder Requirements Validation

Preceding Process
Planning Process
Sub-process 7
Requirements Definition Process
Sub-process 15

Inputs
- Validation Plan (SP 7)
- Other Stakeholder Requirements (SP 15)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents

Purpose
Ensure that the set of defined other stakeholder requirements agrees with other stakeholder needs and expectations with respect to the system.

Tasks
a) Select the methods and define the procedures for validating that the set of other stakeholder requirements from Sub-process 15 is consistent with the level of system structure, enterprise-based life-cycle phase, and Validation Plan, as appropriate.
b) Analyze and compare the identified, derived, and collected other stakeholder requirements to the set of defined other stakeholder requirements, to determine downward traceability.
c) Analyze and compare the set of defined other stakeholder requirements to the identified, derived, and collected other stakeholder requirements, to deterimine upward traceability.
d) Identify and resolve variances, voids, and conflicts (orphans).
e) Record validation results in the established enterprise data repository.

Agents
Systems Engineering
Design Team
R&M
Safety
Supportability/Testability

Tools
Requirements Traceability Matrix Format
Rqmts Mgmt & Sys Arch Db

Next Process
Control Process
Sub-process 12
Requirements Definition Process
Sub-process 15

Outputs
All outputs should be archived (SP 12)
- Validation methods & procedures (SP 27)
- Requirements Traceability Matrix (SP 27)
- Other stakeholder requirements validation revisions (SP 15)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents

References
Standard References

Metrics and Measures
Percent of Other Stakeholder Requirements downward traceable
Percent of Other Stakeholder Requirements upward traceable
Percent of assumptions for Other Stakeholder Requirements reviewed and approved
Percent of changed Other Stakeholder Requirements revalidated

Sub-process 28: System Technical Requirements Validation

Preceding Process
Planning Process
Sub-process 7
Requirements Definition Process
Sub-process 16

Inputs
- Validation Plan (SP 7)
- System Technical Requirements (including Design Information and ICD/CDD revisions) (SP 16)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents

Purpose
Ensure that the set of defined system technical requirements agrees with validated acquirer and other stakeholder requirements.

Tasks
a) Select the methods and define the procedures for validating that the set of system technical requirements from Sub-process 16 is consistent with the level of system structure, enterprise-based life-cycle phase, and Validation Plan.
b) Analyze and compare the set of validated acquirer and other stakeholder requirements to the set of defined system techncial requirements, to determine downward traceability.
c) Analyze and compare the set of defined system techncial requirements to the validated set of acquirer and other stakeholder requirements, to determine upward traceability.
d) Analyze assumptions make with respect to defining system technical requirements to ensure that they are consistent with the system being engineered.
e) Analyze system technical requirements that have been defined as essential for the design effort for other life-cycle considerations for which there is no parent requirement in the set of acquirer and other stakeholder requirements.
f) Identify and resolve variances, voids, and conflicts.
g) Revalidate ths system technical requirements whenever a requirement change is made that affects the acquirer requirements, other stakeholder requirements, or system technical requirements.
h) Record validation results in the established enterprise data repository.

Agents
Systems Engineering
Design Team
R&M
Safety
Supportablity/Testability

Tools
Requirements Traceability Matrix Format
Rqmts Mgmt & Sys Arch Db

Next Process
Control Process
Sub-process 12
Requirements Definition Process
Sub-process 16

Outputs
All outputs should be archived SP 12
- Validation Methods & Procedures (SP 28)
- Requirements Traceability Matrix (SP 28)
- System technical requirements validation revisions (SP 16)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents

References
Standard References

Metrics and Measures
Percent of System Technical Requirements downward traceable
Percent of System Technical Requirements upward traceable
Percent of assumptions for System Technical Requirements reviewed and approved
Percent of changed System Technical Requirements revalidated

Sub-process 29: Logical Solution Representations Validation

Preceding Process
Planning Process
Sub-process 7
Solution Definition Process
Sub-process 17

Inputs
- Validation Plan (SP 7)
- Logical Solution Representation (SP 17)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents

Purpose
Ensure that the set of logical solution representations agrees with the appropriately assigned subset of system technical requirements.

Tasks
a) Select the methods and define the procedures for validating that the sets of logical solution representations and derived technical requirements from Sub-process 17 are consistent with the level of system structure, enterprise-based life-cycle phase, and Validation Plan, as appropriate.
b) Analyze and compare the set of validated system technical requirements to the set of defined logical solution representations and derived techical requirements, to determine downward traceability.
c) Analyze and compare the set of defined logical solution representations, derived technical requirements, and any unassigned system technical requirements to the validated set of system technical requirements, to determine upward treaceability.
d) Analyze assumptions made with respect to defining sets of logical solution representations and derved technical requirements to ensure that they are consistent with the system technical requirements and the system being engineered.
e) Identify and resolve variances, voids, and conflicts (orphans).
f) Revalidate the sets of logical solution representations whenever a requirement change is made that affects the acquirer requirements, other stakeholder requirements, system technical requirements, or sets of defined logical solution representations and derived technical requirements.
g) Record validation results in the established enterprise data repository.

Agents
Systems Engineering
R&M
Safety
Supportablity/Testability

Tools
Requirements Traceability Matrix Format
Rqmts Mgmt & Sys Arch Db

Next Process
Control Process
Sub-process 12
Solution Definition Process
Sub-process 17

Outputs
- **All outputs should be archived SP 12**Validation Methods & Procedures (SP 29)
- Requirements Traceability Matrix (SP 29)
- Logical Solution Representation validation revisions (SP 17)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents

References
Standard References

Metrics and Measures
Percent of Logical Solution Representation downward traceable
Percent of Logical Solution Representation upward traceable
Percent of assumptions for Logical Solution reviewed and approved
Percent of changed Logical Solution Representation revalidated

Sub-process 30: Design Solution Verification

Preceding Process
Planning Process
Sub-process 7, 8
Requirements Definition Process
Sub-process 16
Solution Definition Process
Sub-process 18, 19

Inputs
- Verification Plan (including the VCRM) (SP 7)
- SEP or SDP (SP 7)
- TEMP (SP 7)
- IV&V Plan (SP 7)
- TWP (SP 8)
- SOO (SP 8)
- SOW (SP 8)
- System Technical Requirements (SP 16)
- Selected physical solution representation (SP 18)
- Specified Requirements (SP 19)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents

Purpose
Verify that each end product defined by the system design solution conforms to the requirements of the selected physical solution representation for Hardware and Software (if applicable).

Tasks
a) Plan the design solution verification in accordance with the Verification Plan, agreement, applicable enterprise-based life-cycle phase, and to the level in the system structure.
b) Perform the planned design solution verification using the selection methods and procedures within the established verification environment.
c) Reverify according to a redesign verification plan, test method, or procedure when variances were determined to be caused by poor verification or inadequate verification environmental preparation.
d) Record verification results, including: corrective actions taken; lessons learned; outcomes achieved; Trade-off, effectiveness, and risk analyses completed with resulting key decisions; test activities completed; variances; and the verified design solution in the established enterprised data repository.

Agents
Manufacturing
Logistics
Product Assurance – Speciality Eng.
Software Development
Systems Engineering
T & E

Tools
Modeling & Simulation
Stress Testing
Software Analysis Tools
Integrated Architecture products
Rqmt Management Tools Summary

Next Process
Assessment Process
Sub-process 10, 11
Control Process
Sub-process 12
Solution Definition Process
Sub-process 19
System Verification Process
Sub-process 31

Outputs
All outputs should be archived SP 12
- Demonstrated Test Readiness Report (DTRR) (SP 12, 31)
- Design solution verification report (SP 31)
- Design Solution Deficiency andDiscrepancy Reports (SP 10, 11, 12, 19, 31)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents

References
Standard References
ANSI/EAI 632 (Para. 4.5.2) Process for Engineering a System
TE000-AB-GTP-010 Parts Derating Requirements and Applications Manual for Navy Electronic Equipment
Equivalent to MIL-STD-2164 Environmental Stress Screening Process for Electronic Equipment
Equivalent to MIL-STD-454 Standard General Requirements for Electronic Equipment
DOD 4245.7-M Transition From Development to Production
NAVSO P-6071 Best Practices-The Transition from Development to Production
CMMI 2001

Metrics and Measures
Test Schedules (including dates, milestones, etc.) are met.

Sub-process 31: End Product Verification

Preceding Process
Supply Process
  Sub-process 1
Planning Process
  Sub-process 7
Requirements Definition Process
  Sub-process 14
Solution Definition Process
  Sub-process 19
System Verification Process
  Sub-process 30

Next Process
Assessment Process
  Sub-process 10, 11
Control Process
  Sub-process 12
Solution Definition Process
  Sub-process 19
End Products Validation Process
  Sub-process 33

Inputs
- End Products ("as built" production representative) (SP 1)
- Enabling Products (SP 1)
- TEMP (SP 7)
- Verification Plan including VCRM (SP 7)
- ICD – formerly MNS (SP 14)
- CDD or CPD – formerly ORD (SP 14)
- Specified requirements (SP 19)
- DTRR (SP 30)
- Design solution verification report (SP 30)
- Design solution deficiency and discrepancy report (SP 30)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents (approved Test Plan including risk mitigation)

Purpose
Verify that an end product ("as built" production representative) to be delivered to an acquirer conforms to its specified requirements.

Tasks
a) Plan the end product (system and subsystem, "as built") verification in accordance with the Verification Plan, agreement (normally associated with detailed developmental test plans), applicable enterprise-based life cycle-phase, and level in the system structure.
b) Verify the end product (system/subsystem, "as built"), using the selected methods and procedures within the established verification environment.
c) Reverify according to a redesigned verification plan, test method, or procedure when variances were determined to be caused by poor verification or inadequate verification environmental preparation.
d) Record verificaiton results, including corrective actions taken; lessons learned; outcomes achieved; Trade-off, effectiveness, and risk analyses completed with resulting key decisions; test activities completed; variances; and the verified end products in the established enterprise data repository.

Agents
T&E
R&M
Systems Engineering
Human Factors
Acquirer
PEO/PM
Operators / Users
Developer / Contractor

Tools
Ranges (flight test)
Test Plans (System, Subsystem, and Integrated)
Facilities/Labs (ground tests)
Aircraft and systems, and ALL supporting systems under test
Flight Clearance
Deficiency Database

Outputs
All outputs should be archived SP 12
- Detailed developmental test plans (SP 31)
- Developmental test methods (SP 31)
- Developmental test procedures (SP 31)
- End Product Deficiency and Discrepancy Reports (SP 10, 11, 19)
- DT/OT Transition Report (SP 33)
- Report of Test Results with limitations and constraints for OT (SP 33)
- Operational Advisory Document (SP 33)

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents. (Completion of the Verification phase evaluated results and reported conclusions.)

References
Standard References
NAVAIR Test Plan Instruction 3960.2 series
NATOPS Flight and Weapon Systems Manual (for each platform)
Range Safety Operation Guides (for each range operated on)
Test Squadron SOP's/ Facility SOP's
U.S. Naval Test Pilot School Flight Test Manual
Software Requirements Specifications
SAR's/STR's
NAVAIR NTAB Instruction 3960.5 Manufacturers Specifications
CMMI 2001

Metrics and Measures
Deficiencies (Part I, II, III) based on verification
- Specification Compliance
- TEMP Compliance
- Mission Relation/Impact

Earned Value Measurements (cost, performance, test completion, ground/lab/flight hours, and data points)
Test Schedule
End Products Deficiency Reports

Sub-process 32: Enabling Products Readiness

Preceding Process
Supply Process
Sub-process 1
Planning Process
Sub-process 5
Solution Definition Process
Sub-process 19

Purpose
Determine the readiness of enabling products for development, production, test, deployment/installation, training, support/ maintenance, and retirement or disposal.

Next Process
Control Process
Sub-process 12
Transition to Use Process
Sub-process 21
System Verification Process
Sub-process 32

Inputs
- Enabling Products (SP 1)
- List of: Methods and Tools, Facilities, Equipment, Training (SP 5)
- Specified Requirements (SP 19)
- Enabling Products Development Projects (SP 19)

Tasks
a) Plan enabling product readiness determination and associated process proofing.
b) Do the planned enabling product readiness determination and associated process proofing.
c) Reaccomplish readiness determination when variances were determined to be caused by poor readiness or proofing conduct, or by indadequate environmental preparation.
d) Record readiness determination and process proofing results; and the verified enabling products and proofing of associated processes in the established enterprise data repository.

Outputs
All outputs should be archived SP12
- Enabling Products Readiness Determination (SP 12, 21)
- Enabling Products Readiness Assessment Plan (SP 32)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agents

Agents
System Engineering
Logistics
T&E
Training
Manufacturing
Program Manager

Tools
Enterprise Data Repository, Integrated Architecture Products, Manufacturing Tooling, TPM Tracking tools/ Schedules, Test Equipment & Software, Statistical Process Control, Manufacturing Simulations, CAD/CAM, Removal Tools, Flight Simulators, Training Manuals, Readiness archives and databases

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents

References
Standard References
DOD 5000.2R, Parts 3.3, 5.2, & 7.4
MIL-STD-1521B
MIL-STD-499B, Parts 5.5 & 5.7
NAVSO P-6071 Best Practices, Sections 5.0, 6.0, 7.0, 9.0, & 10.4
DOD 4245.7-M Transition from Development to Production Sections, 4.0, 5.0, 6.0, 8.0, & 9.0
DAU Program Manager's Tool Kit
CMMI 2001

Metrics and Measures
Adherence to Schedule and Progress versus Plan
Sub-process execution time and cost
System Definition Detail
Technical Performance Measurement Resolution
- Availability
- Reliability
- Capability
- Effectiveness

Process Control Matrices

Sub-process 33: End Products Validation

Preceding Process
Supply Process
Sub-process 1
Planning Process
Sub-process 7
Requirements Definition Process
Sub-process 14
System Verification Process
Sub-process 31

Inputs
- End Products (SP 1)
- Enabling Products (SP 1)
- Validation Plan (Operational Test Plan) (SP 7)
- TEMP (SP 7)
- OTRR (Internal or SP 7)
- ICD – formerly MNS (SP 14)
- CDD – formerly ORD (SP 14)
- DT/OT Transition Report (SP 31)
- Report of Test Results with limitations and constraints for (OT) (SP 31)
- Operational Advisory Document (SP 31)

Purpose
Ensure that an end product, or an aggregation of end products, conforms to its validated acquirer requirements.

Tasks
a) Determine the type of end product validation required and the exit criteria, including the acquirer requirements applicable to the sytem end products being validated.
b) Acquire the test article, or aggregation of end products, for the validation as appropriate to the enterprise-based life-cycle phase and level of system structure.
c) Conduct the end products validation in accordance with the Validation Plan, as required in the agreement, to show conformance with appropriate requirements; collect and analyze validation outcomes to identify any variances; and do appropriate process tasks to resolve variances and repeat appropriate verifications and validations.
d) Revalidate with improved or corrected procedures and equipment when variances were caused by poor test conduct and conditions.
e) Record the validation outcomes, procedures, assumptions, lessons learned, and other pertinent information about the validation and results in the established enterprise data repository, to provide traceability.

Next Process
Acquisition Process
Sub-process 2
Control Process
Sub-process 12
Solution Definition Process
Sub-process 19
Implementation Process
Sub-process 20

Outputs
All outputs should be archived SP 12
- OTRR Plan (SP 33)
- OTRR certification message (SP 2)
- OT/FOT&E Report (SP 19, 20)

Entry Criteria
Inputs have been reviewed and approved by the appropriate agent. For most programs, the appropriate Development Test (DT) must have been successfully completed and a DT report issued.

Agents
OPTEVFOR
DOT&E
Systems Engineering
T&E
COMOPTEVFOR

Tools
SIL
HIL
M&S
Flight Test

Exit Criteria
Outputs have been reviewed and approved by the appropriate agents.

References
Standard References
DRAFT MIL-STD-499B
NAVAIR 3960.2 Series
CMMI 2001
MIL-STD-3960.2
IEEE/EIA 12201

Metrics and Measures
OTRR is achieved within program schedule
Operational test procedures and processes are carried out according to the TEMP

Appendix I – Acronyms

ACAT	Acquisition Category
ACWP	Actual Cost of Work Performed
AIAA	American Institute of Aeronautics and Astronautics
ANSI	American National Standards Institute
AOA	Analysis of Alternatives (formerly called COEA)
APB	Acquisition Program Baseline
APMSE	Assistant Program Manager for Systems Engineering
AVDEP-HDBK	
AWESim™	Simulation software
BCWP	Budget Cost of Work Performed
BCWS	Budget Cost of Work Scheduled
BES	Budget Estimate Submission
BPS	BITs per second
C/SSR	Cost/Schedule Status Reports
C4ISR	Command, Control, Communication, Computers, Intelligence
CAD	Computer Aided Design
CAE	Component Acquisition Executive; Computer Aided Engineering
CAIV	Cost as an Independent Variable
CAM	Computer Aided Manufacturing
CBD	Commerce Business Daily
CDD	Capability Development Document
CDR	Critical Design Review
CDRL	Contract Data Requirements List
CDS	Concept Description Sheet
CE	Concept Exploration
CER	Cost Estimating Relationships
CI	Configuration Item
CITIS	Contractor Integrated Technical Information Services
CM	Configuration Management; Contract Management
CMMI	Capability Maturity Model Integration
COCOMO	Constructive Cost Model
COEA	Cost of Operations Effectiveness Analysis (obsolete – see AOA)
COMOPTEVFOR	Commander, Operational Test and Evaluation Force (Navy)
CORE™	Requirements Management & System Architecture Database Software
COTS	Commercial Off The Shelf
CPI	Cost Performance Index
CPM	Critical Path Method
CPR	Cost Performance Reports
CRLCMP	Computer Resources Life Cycle Management Plan
CSCI	Computer Software Configuation Item (aka SI)
CV	Cost variance
CWBS	Contract Work Breakdown Structure

DAD	Defense Acquisition Deskbook
dB	Decibel
DBDD	Database Design Description
Deg	Degree
DFARs	Defense Federal Acquisition Regulations
DID	Data Item Description
DCMA	Defense Contractor Management Agency
DoD	Department of Defense
DoDSSP	Department of Defense Single Stock Point
DoN	Department of Navy
DOORS	Demonstration of Dynamic Object-Oriented Requirements System
DOT&E	Director, Operational Test and Evaluation (OSD)
DS	Design Sheet
DSMC	Defense Systems Management College
DT	Developmental Test
DTR	Derived Technical Requirements
DTRR	Demonstration Test Readiness Report
EDA	Electronic Design Automation
EIA	Electronic Industries Alliance
EMC	Electromagnetic Compatibility
EMD	Engineering and Manufacturing Development replaced with System Development and Demonstration (SDD)
EMI	Electromagnetic Interference
ENMIG	Earned Value Management Implementation Guide
EVM	Earned Value Management
EVMS	Earned Value Management System
EXT	External supplier or acquirer, i.e., associated product is external, unspecified, and neither an input from, or an output for, a sub-process.
FAR	Federal Acquisition Regulation
FCA	Functional Configuration Audit
FFBD	Functional Flow Block Diagram
FIS	Facility Interface Sheet
FMEA	Failure Modes and Effectiveness Analysis
FMECA	Failure Modes and Effectiveness Critical Analysis
FOT&E	Follow-On Test & Evaluation
FPT	Fleet Project Team
FST	Fleet Support Team
Ft	Feet
FTA	Fault-tree analysis
FTEG	Flight Test Engineering Guide
GFE	Government Furnished Equipment
GHz	Gigahertz
HIL	Hardware in-the-Loop
hr	Hour
HWCI	Hardware Configuration Item

Hz	Hertz
ICD	Initial Capabilities Document
IDD	Interface Design Description
IDEF	Integrated Definition
IEC	International Electrotechnical Committee
IEEE	Institute of Electrical and Electronics Engineers
ILS	Integrated Logistics Support
IMS	Integrated Master Schedule
INCOSE	International Council on Systems Engineering
IOC	Initial operational capability
IPPD	Integrated Product and Process Development
IPT	Integrated Product Team
IRD	Interface Requirements Document
IRS	Interface Requirements Specification
ISBN	International Standard Book Number
ISEA	In-Service Engineering Agent
ISO	International Standards Organization
IV&V	Independent Verification & Validation
JSSG	Joint Services Specification Guides
KPP	Key Performance Parameters
lb	Pound
LRIP	Low-Rate Initial Production
LSA	Logistics Support Analysis
M&S	Modeling and Simulation
MAA	Mission Area Analysis
MAIS	Major Automated Information System
MAPP	Master Acquisition Planning Program
MDAP	Major Defense Acquisition Program
MHz	Megahertz
mi	Mile
MILHDBK	Military Handbook
MILSATCOMM	Military Satellite Communication
MILSTD	Military Standard
min	Minute
MIPR	Military Interservice Procurement Request
MNS	Mission Need Statement
MOE	Measure of Effectiveness
MOP	Measure of Performance; Memorandum of Policy
MOS	Measures of Suitability
MS or M/S	Milestone
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
NALCOMIS	Naval Aviation Logistics Command Management Information System
NASA	National Aeronautics and Space Administration
NAVAIR	Naval Air Systems Command

NAVAIRINST	Naval Air Systems Command Instruction
NAVSO	Navy Support Office
NAWCWD	Naval Air Warfare Center Weapons Division
NDI	Non-Developmental Item
NTAB	Naval Technical Assurance Board
OOA	Object Oriented Analysis
OPEVAL	Operational Evaluation
OPNAV	Office of the Chief of Naval Operations
Ops	Operations
OPTEVOR	Operation Test and Evaluation Command
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
OT	Operational Test
OT&E	Operational Test & Evaluation
OTRR	Operational Test Readiness Review
P^3I	Pre-Plan Product Improvement
PCA	Physical Configuration Audit
PCO	Procurement Contracting Officer
PDR	Preliminary Design Review
PDRR	Program Definition and Risk Reduction
PDT	Product Development Team
PEO	Program Executive Officer
PERT	Program Evaluation Readiness Technique
PM	Program Manager
PMB	Performance Measurement Baseline
PMBOK	Project Management Body of Knowledge
POA&M	Plan of Actions and Milestones
POG	Program Operating Guide
PRR	Production Readiness Review
QA	Quality Assurance
QFD	Quality Functional Deployment
R&M	Reliability & Maintainability
R&D	Research and Development
RAS	Requirement Allocation Sheet
RDT&E	Research, Development, Test and Evaluation
RFI	Request for Information
RFP	Request for Proposal
S/N	Serial Number
SBD	Schematic Block Diagram
SDD	Software Design Description
SDP	Software Development Plan
SE	Systems Engineering
sec	Second
SEER-SEM	Software Development Tool

SEI	Software Engineering Institute
SEMP	Systems Engineering Management Plan
SEP	Systems Engineering Plan, formerly Systems Engineering Management Plan
SEPWG	Systems Engineering Process Working Group
SFR	System Functional Review
SIL	Software in-the-Loop
SLAM	Queuing methodology software
SLATE™	Requirements Management & System Architecture Database Software
SME	Subject Matter Expert
SOO	Statement Of Objectives
SOP	Standard Operating Procedures
SOW	Statement of Work
SPC	Statistical Process Control
SPI	Schedule Performance Index
SPS	Software Product Specification
sq	Square
SRD	System Requirements Document
SRR	System Requirements Review
SRS	Software Requirements Specification
SSDD	System/Segment Design Document
SSS	System/Subsystem Specification
STR	System Technical Requirements
SV	Schedule variance
SVD	Software Version Description
Syscom	Systems Command
T&E	Test and Evaluation
TAA	Team Assignment Agreement
TBD	To Be Determined
TBR	To Be Reviewed
TDP	Technical Data Package
TEMP	Test and Evaluation Management Plan
TEPMG	Test and Evaluation Process Working Group
TLS	Time Line Sheet
TOC	Total Ownership Costs
TPM	Technical Performance Measures/Measurement
TRS	Test Requirements Sheet
TWP	Team Work Plan
UML	Unified Modeling Language
VBA	Visual Basic Programming
VCRM	Verification Compliance Requirement Matrix
W	Watts
WBS	Work Breakdown Structure
Wt	Weight

Appendix J – Naval References

Filename	Reference Info (Note: cancelled documents begin with an 'X' and are noted in the title these are the best known references at the time of publishing, but are ONLY to be used as references.)
AIAA OCD Prep	American Institute of Aeronautics and Astronautics (AIAA) (1992). Operational Concept Document (OCD) Preparation Guidelines.
Blanchard SE	Blanchard, Benjamin S. and Fabryncky, W.J. (1997). Systems Engineering and Analysis (3rd ed.). Upper Saddle River, NJ: Prentice Hall
Booch OOA	Booch, Grady. Object- oriented Analysis and Design with Applications (2nd ed.) (1994). Santa Clara, CA: Benjamin/Cummings
C4ISR	Department of Defense: C4ISR Architecture Working Group (18 December 1997). C4ISR Architecture Framework Version 2.0. Arlington, VA: Author
CMMI℠	CMMI℠ Software Engineering Institute, Carnegie Mellon University. (2002) Capability Maturity Model ® Integration for Systems Engineering, Software Engineering, Integrated Product and Process Development, and Supplier Sourcing. Pittsburgh, PA: Author
formerly DAD – AKSS	AT&L Knowledge Sharing System (AKSS). **http://deskbook.dau.mil/jsp/default.jsp**
DAU SE Fundamentals	Defense Acquisition University Press (2001). Systems Engineering Fundamentals. Fort Belvoir, VA: Author
DAU Program Manager's Tool Kit	Defense Acquisition University Press (2004). DAU Program Manager's Tool Kit. Fort Belvoir, VA: Author.
DAU Risk Management Guide	Defense Acquisition University Press (June 2003). Risk Management Guide for DoD Acquisition. Fort Belvoir, VA: Author
DSMC Virtual Prototyping-Concept to Production	Defense System Management College (1993). Press Report of the 1992-1993 Military Research Fellows, Virtual Prototyping—Concept to Production. Fort Belvoir, VA: Garcia, A. B., Gocke, R. P., & Johnson Jr., N. P.
DD 1423-2	Contract Data Requirements List (1996), DD Form 1423-2
DD 250	Material Inspection and Receiving Report (2000), DD Form 250
DD 254	Contract Security Classification Specifiction (1999), DD Form 254
DI-GDRQ-81222	Department of Defense. Requirement Allocation Sheets (RAS) Data Item Description (DI-IPSC-81222). Arlington, VA: Author
DI-CMAN-80858B	Department of Defense. Contractor's Configuration Management Plan (DI-CMAN-80858). Arlington, VA: Author
DI-ILSS-81163A	Department of Defense. Failure Modes, Effects, and Criticality Analysis (FMECA) Report (DI-ILSS-81163A). Arlington, VA: Author
DI-IPSC-81430	Department of Defense. Operational Concept Description (OCD) Data Item Description (DI-IPSC-81430). Arlington, VA: Author
DI-IPSC-81431	Department of Defense. System/Subsystem Specification (SSS) Data Item Description (DI-IPSC-81431). Arlington, VA: Author
DI-IPSC-81432	Department of Defense. System Architecture Design (SSDD) Data Item Description (DI-IPSC-81432). Arlington, VA: Author
DI-IPSC-81433	Department of Defense. Software Requirements Specification (SRS) Data Item Description (DI-IPSC-81433). Arlington, VA: Author
DI-IPSC-81434	Department of Defense. Interface Requirements Specification (IRS) Data Item Description (DI-IPSC-81434). Arlington, VA: Author
DI-IPSC-81435	Department of Defense. Software Design Description (SDD) Data Item Description (DI-IPSC-81435). Arlington, VA: Author
DI-IPSC-81436	Department of Defense. Interface Design Description (IDD) Data Item Description (DI-IPSC-81436). Arlington, VA: Author

Filename	Reference Info (Note: cancelled documents begin with an 'X' and are noted in the title these are the best known references at the time of publishing, but are ONLY to be used as references.)
DI-IPSC-81437	Department of Defense. Database Design Description (DBDD) Data Item Description (DI-IPSC-81437). Arlington, VA: Author
DI-IPSC-81441	Department of Defense. Software Product Specification (SPS) Data Item Description (DI-IPSC-81441). Arlington, VA: Author
DI-IPSC-81442	Department of Defense. User Software Version Description (SVD) Data Item Description (DI-IPSC-81442). Arlington, VA: Author
DI-MGMT-81024	Department of Defense. System Engineering Management Plan (SEMP) (DI-MGMT-81024). Arlington, VA: Author
DI-MISC-81180	Department of Defense. Manufacturing Technology Demonstration Plan (DI-MISC-81180). Arlington, VA: Author
DI-MISC-81183A	Department of Defense. Integrated Master Schedule (IMS) Data Item Description (DI-MISC-81183A). Arlington, VA: Author
DI-NDTI-80566	Department of Defense. Test Plan (DI-NDTI-80566). Arlington, VA: Author
DoD 4245.7-M	Department of Defense. (1985) Transition from Development to Production (DoD 4245.7-M). Arlington, VA: Author.
DoD 5000 Series	Navy Acquisition and Business Management website: http://www.acq.osd.mil
DoD 5000.1	Department of Defense. (2003) The Defense Acquisition System (DoD 5000.1). Fort Belvoir, VA: .Author. Note: Select DoD 5000 Series to access most current issuance.
DoD 5000.2	Department of Defense. (2003) Operation of the Defense Acquisition System (DoDI 5000.2). Fort Belvoir, VA: .Author. Note: Select DoD 5000 Series to access most current issuance.
DoD 5000.2-R	Department of Defense. (2003) (Interim) Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) Acquisition Programs (DoD 5000.2-R). Fort Belvoir, VA: .Author. Note: Select DoD 5000 Series to access most current issuance. To be replaced with DoD Acquisition Guidebook.
FAR/DFAR	Federal Acquisition Regulation (**http://www.arnet.gov/far/**) / Defense Federal Acquisition Regulation (**http://www.acq.osd.mil/dp/dars/dfars.html**)
EIA-632	Electronic Industries Alliance. (1999). EIA-632 Processes for Engineering a System. Arlington, VA.
EIA-748	Electronic Industries Alliance. (1998). EIA-632 Earned Value Management Systems. Arlington, VA
Grady SE Plan	Grady, Jeffery O. (1994). System Engineering Planning and Enterprise Identity. CRC Press.
IEEE 1220	Institute of Electrical and Electronics Engineers, Information Handling Services (1999). IEEE Standard for Application and Management of the Systems Engineering Process (IEEE Std 1220-1998). New York, NY.
INCOSE SE Hdbk	International Council on Systems Engineering (1998) Systems Engineering Handbook (Release 1.0). Seattle, WA. **www.incose.org**
IPPD Hdbk	Department of Defense (1998). DoD Integrated Product and Process Development (IPPD) Handbook. Washington, DC: Author
DoD Joint Technical Architecture	DoD JTA as promulgated by DoD Memorandum, dated 19 August 2003
Lacy SE Mgmt	Lacy, James A. (1992). Systems Engineering Management. Jim Lacy.
Lake 1999	Lake, Jerry. 1999. World Class Example. Unpublished
Top 11 Risk	Office of Assistant Secretary to the Navy (RD&A) Acquisition and Business Management. (1998) Top Eleven Ways to Manage Risk. Philadelphia, PA: DODSSP

Filename	**Reference Info** (Note: cancelled documents begin with an 'X' and are noted in the title these are the best known references at the time of publishing, but are ONLY to be used as references.)
Martin SE Guide	Martin, James N. (1996) Systems Engineering Guidebook. CRC Press
MIL-HDBK-512A	Department of Defense. (2001) Handbook for Parts Management (MIL-HDBK-512A). Fort Belvoir, VA. Author
MIL-HDBK-61A	Department of Defense. (2001) Handbook for Configuration Management Guidance (MIL-HDBK-61A). Fort Belvoir, VA. Author
MIL-HDBK-245D	Department of Defense. (1996) Handbook for Preparation of Statement of Work (SOW) (MIL-HDBK-245D). Fort Belvoir, VA. Author
MIL-HDBK-881	Department of Defense. (1998) Work Breakdown Structure (WBS) (MIL-HDBK-881). Fort Belvoir, VA. Author
MIL-STD-100G	Department of Defense. (1997) Standard Practice for Engineering Drawings (MIL-STD 100G). Fort Belvoir, VA: Author
MIL-STD-1629A **MIL-STD-1629A N1** **MIL-STD-1629A N2** **MIL-STD-1629A N3**	Department of Defense. Procedures for Performing a Failure Mode, Effects and Criticality Analysis (MIL-STD-1629A) (Notes 1-3). Arlington, VA: Author
MIL-STD-498	Department of Defense. (1994) Software Development and Documentation (MIL-STD-498). Fort Belvoir, VA: Author
MIL-STD-499B	Department of Defense. (XxXx) DRAFT Systems Engineering (MIL-STD 499B). Fort Belvoir, VA: Author
MIL-STD-961D **MIL-STD-961D N1**	Department of Defense. (1995) Standard Practice for Defense Specifications (MIL-STD 961D). Fort Belvoir, VA: Author
NAVAIR Acquisition Guide	Naval Air Systems Command (NAVAIR). (January 2004) NAVAIR Acquisition Guide (*NAVAIR #*). Author.
NAVAIR Design Review Handbook (AIR 4.1)	Naval Air Systems Command (NAVAIR). (January 2001) NAVAIR Design Review Handbook (AIR 4.1) (*NAVAIR #*). Author.
NAVAIR Risk Management Guide	Naval Air Systems Command (NAVAIR). (*expect* July 2004 *approval*) DRAFT NAVAIR Risk Management Guide (*NAVAIR #*). Author.
NAVAIRINST 3960.2C	Naval Air Systems Command (NAVAIR). (1994) Test and Evaluation (NAVAIRINST 3960.2C). Author.
NAVAIRINST 4130.1C	Naval Air Systems Command (NAVAIR). (1992) Configuration Management Policy. (NAVAIRINST 4130.1C). Author.
NAVAIRINST 4200.36C	Naval Air Systems Command (NAVAIR). (2004) Acquisition Plans. (NAVAIRINST 4200.36C). Author.
NAVAIR INST 4355.19B	Naval Air Systems Command (NAVAIR). (2003) Systems Engineering Technical Review Process. (NAVAIR INST 4355.19B). Author.
NAVAIRINST 5000.21	Naval Air Systems Command (NAVAIR). (2003) Program/Project Risk Management. (NAVAIRINST 5000.21). Author.
NAVAIRINST 5400.154	Naval Air Systems Command (NAVAIR). (2000) Team Assignment Agreement. (NAVAIRINST 5400.154). Author.
NAVSO P-6071	Department of the Navy. (1986) Best Practices (How to Avoid Suprises in the World's Most Complicated Technical Process) The Transition from Development to Production. (NAVSO P-6071). Author.
Oliver Eng Sys	Oliver. David W., et al, (1997) Engineering Complex Systems with Models and Objects. McGraw-Hill Companies
SD-2	The Office of Under Secretary of Defense for Acquisition and Technology. (1996) Buying Commercial and Non-Developmental Items: A Handbook (SD-2). Philadelphia, PA: DODSSP
SD-5	The Office of Under Secretary of Defense for Acquisition and Technology. (1997) Market Research (SD-5). Philadelphia, PA: DODSSP
Yourdon	Yourdon, Edward. (1989). Modern Structured Analysis. Upper Saddle River, NJ. Prentice Hall

Office of the Under Secretary of Defense for ACQWEB Acquisition, Technology, & Logistics

Home | Search | Help | Contact Us

SECURITY & PRIVACY DISCLAIMER

Search

Submit

Welcome

Home

AT&L Documents

Acquisition FAQs

Archived Highlights

Navigate

Office Navigator

DoD Root Certificate Download

Search

Help

Feedback

Top Sites

Video Services

DFARS

DoD 5000.1 & 5000.2

AKSS/Deskbook

UAV Roadmap

Contract Pricing Guides

Related Sites

Defense LINK - The U.S.

FIRSTGOV - The U.S.

9/11 Ribbon

Contact the Webmaster at: ATL-Webmaster@osd.mil

ACQWeb Highlights

July 27, 2004

I&E Business Transformation Seal

The I&E Business Transformation Directorate was established in May of 2003 to lead process change across all installation and environment business areas and to support I&E Domian governance within the Business Management Modernization Program (BMMP).

Department of Defense Military

Department of Defense Military Equipment Valuation

The PP&E Policy Office, OUSD(AT&L), leads the Department's efforts to implement the new Federal Accounting Standards Advisory Board's (FASAB) accounting and reporting standard for military equipment in order to ensure that a standard, consistent approach is used across the Department. For more information, please visit the Military Equipment Valuation website.

Corrosion Prevention and Control Program Training

Corrosion Prevention and Control Program training is now available at CPC Training. It is designed to assist in the implementation of the policy directed by the Acting USD (AT&L) Memorandum of 12 November 2003 that states that acquisition programs are to address corrosion prevention at the earliest stages of development and that Corrosion Prevention and Control (CPC) planning is to be addressed in conjunction with milestone reviews. CPC Program training CDs can be requested at cpcprogramtraining@dau.mil

---

Energy 2004 Logo

Energy 2004 Workshop

The Energy 2004 workshop, scheduled for August 8-11 in Rochester, NY, is designed for federal, state, local and private sector energy managers, energy service companies, utilities, procurement officials, engineers and other energy professionals. Topics that will be covered include establishing or improving an energy management program, procuring renewable and energy-efficient products and services, and incorporating sustainable design concepts. For more information, please visit the Energy 2004 website.

Acquisition Community Connection Logo

The Acquisition Community Connection (ACC) is the collaborative arm of the AT&L Knowledge System that complements the existing information resources located on the AT&L Knowledge Sharing System (AKSS). The ACC consists of publicly accessible knowledge communities whose goal is connecting people with know-how across all DoD organizations and industry.

ACQWeb Orientation

Welcome to ACQWeb

ACQWeb is the online home of the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics.

ACQWeb Help Section

To learn more about ACQWeb or find answers to your technical problems, please visit our help section.

ACQWeb Feedback

Thank you for using ACQWeb! Please contact the webmaster with any questions, comments or suggestions. We are always looking for ways to help you get the information you need.

Featured Site of the Month

Link for Advanced Systems & Concepts

Advance Systems & Concepts

This page was last updated:
Thursday, 7/1/04 8:46

The Deputy Under Secretary of Defense (Advanced Systems & Concepts) is responsible to the USD (AT&L) for oversight technical transition from Science & Technology to Defense acquisition efforts, and oversight of joint experimentation supporting this technology transition.

[Featured Site of the Month Archives](#)

AKSS Today! *What's new in DoD acquisition.*

AT&L Knowledge Sharing Update

New JCIDS/DoD 5000/PPBE Policy is Available
click here

We want your feedback—again!

DAU Deploys AT&L Knowledge Sharing System (AKSS) 3.0 with Interwoven:

DAU has procured and transitioned the AKSS to the Interwoven Content Management System (CMS), in a technical upgrade designed to improve the timeline for adding and correcting the content of AKSS. To the user, this means that new links and corrections to golden sources, Acquisition, Technology, and Logistics (AT&L) web-sites, training information, guidebooks and handbooks, and other menu driven content, can be added to AKSS almost instantly. Additionally, hot topics and suggested AT&L news articles can be posted to AKSS on the same day that they appear on the web. The user will not see any change in the appearance or functionality of the AKSS, but will find that broken or mis-identified links will be fixed or updated within minutes of discovery. This new CMS capability ensures that AKSS 3.0 will remain a top resource for mandatory AT&L policy and information.

(entire article)

Pilot System to Analyze Defense Spending :

The Defense Department has launched a pilot to help military brass understand what they're buying and where they're buying it. "The department is building a system to pull data from disparate databases for analysis by DOD buying teams," said Mark Krzysko, deputy director of Defense procurement and acquisition policy. The department expects to begin testing the first iteration of the 11-month, $950,000 pilot in October. The project is funded by the Navy Department's eBusiness Operations Office, which recently identified four projects to begin pilot implementation under the Rapid Acquisition Incentive-Net Centricity program for 2004. Krzysko said users will be able to identify procurement trends, buying patterns and opportunities for strategic purchasing, which will result in cost savings and quality improvements. A negative report last year from the General Accounting Office was one catalyst for the project, officials said. Auditors reported that DoD needed to improve the way it manages the $100 billion it spends on services contracts.

(entire article)

Naval Transformation Roadmap:

Naval transformation will support joint transformation by delivering new military capabilities and dramatically enhancing current capabilities to protect and advance America's worldwide interests by assuring access and projecting power from the sea. While the Navy – Marine Corps Team is expanding the entire array of

Reader's Choice

- *CJCS Instructions 3170.01D*
- *CJCS Manual 3170.01*
- *DoDD 5000.1*
- *DoDI 5000.2*
- *FMS Manual*
- *DCMA Instruction/Guidebook*
- *DCAA Manual*
- *FAR*
- *DFARS*
- *Other FAR Supps*
- *DoD 7000.14-R*
- *EI Toolkit*

Suggested Reading

- *Joint Tactical Radio System (JTRS) Architecture is the Basis for International Commercial Standards*
- *Combatant Commanders Need Adaptive, Agile Forces*
- *Army announces modularization schedule through FY07*
- *U.S. Army recognizes its Top Ten Greatest Inventions*

Suggested Reading Previous Postings

New Policy Documents

naval capabilities we provide the Nation, our transformation is centered upon the development of Seabasing: the concepts and capabilities that exploit our command of the sea to project, protect, and sustain integrated warfighting capabilities from the maritime domain. Seabasing and the supporting tools we are developing will usher in dramatic new ways of employing naval forces to deter conflict and, when required, to wage war. Throughout, every aspect of naval transformation will be, first and foremost, committed to and built upon the principles of jointness. Seabasing will provide new naval capability options for use by Joint Force Commanders in innovative combinations with the transformed capabilities of the other Services and Agencies.

(entire article)

→ AKSSToday Previous Postings

What Do You Think

Have you joined a community of practice (COP) ?

○ **Yes** ○ **No** ○ What's a COP?

Vote

View Results

- *OUSD Memo Instructions for Modular Open Systems Approach (MOSA) Implementation*
- *OUSD Memo Amplifying DoDD 5000.1 Guidance Regarding Modular Open Systems Approach (MOSA) Implentation*
- *General Services Administration Acquisition Manual*
- *Navy Marine Corps Acquisition Guide (Revised)*
- *CJCSI 6212.01C INTEROPERABILITY AND SUPPORTABILITY OF INFORMATION TECHNOLOGY AND NATIONAL SECURITY SYSTEMS*

Tip of the Week

Found a Dead Link?

News

- *DoD*
- *Army*
- *Navy*

Privacy and Security* | *Document Management* | *Contact Us* | *Feedback* | *Legal Notices

Web Help Desk
ISSC@dau.mil

INCOSE
International Council on Systems Engineering

Search

go

Advancing the Practice

What is Systems Engineering

Guide to SE Body of Knowledge

Strategic Initiatives

Technical Activities

Standards Update

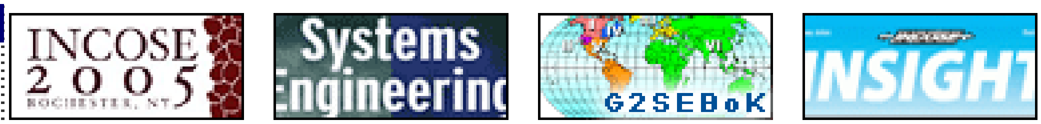
Research

Partnerships

Quick Links

- Find an SE Tool
- Academic Program Directory
- Job Bank
- My Chapter

The International Council on Systems Engineering is a not-for-profit membership organization founded in 1990. INCOSE is an international authoritative body promoting the application of an interdisciplinary approach and means to enable the realization of successful systems.



Current News

New INCOSE Website (05 Jul 04)
Though we are still wrapping up the content and fixing a few issues, we hope you enjoy the new INCOSE website.

INCOSE Products Area Expanded (05 Jun 04)
INCOSE has classified and published all existing INCOSE Systems Engineering Products.

Call for Papers (05 Jun 04)
Share your knowledge and experience at a future INCOSE event.

Defense Acquisition University Joins the INCOSE CAB (01 Jun 04)
We welcome Defense Acquisition University (DAU) as the newest member of our Corporate Advisory Board.

Systems Engineering Handbook v2a Released (01 Jun 04)
Version 2a of the INCOSE Systems Engineering Handbook is now available.

View All News

Upcoming Events

September 15 - 18, 2004
ICSE and INCOSE 2004 Region II Conference

October 25 - 28, 2004
National Defense Industrial Association (NDIA) 7th Annual Systems Engineering Conference

November 02 - 4, 2004
INCOSE Mid-Atlantic Regional Conference 2004 (MARC2004)

November 08 - 10, 2004
Systems Engineering/Test and Evaluation Conference (SETE) 2004

January 28 - February 03, 2005
INCOSE International Workshop 2005

View All Events

Contact INCOSE: +1 206-361-6607 or 800-366-1164 (toll-free U.S.), info@incose.org

Terms of Use | Privacy Statement

Defense Acquisition Regulations Directorate

What's New?. Subscribe to DFARS News DFARS Contact

Defense FAR Supplement (DFARS)

Organization
- DAR Directorate
- DAR Council
- DAR Committee
- DFARS Transformation Homepage

FAR
- GSA
- Hill AFB

DFARS
- DFARS
- Change Notices
- Hill AFB
- Order Code Assignments (formerly in Appendix G)

Subscribe to News Alert
- FAR News
- DFARS News

Class Deviations
- Class Deviations

Guides
- AT&L Knowledge Sharing System
- Contract Pricing
- Small Entity Compliance
- Operating Guide

Out for Public Comment
- FAR Rules
- DFARS Rules
- Info. Collection Requirements

View DFARS Public Comments

Please visit http://www.acq.osd.mil/dpap/dfars/index.htm for the latest version of the DFARS **(DFARS) from the Director of Defense Procurement.**

The 1998 Edition of the DFARS replaces the 1991 Edition. See DFARS Change Notices for links to descriptions of all changes to the 1998 edition.

Browse **the DFARS text in HTML format.** (Best viewed in Internet Explorer 6.0)
Browse **the DFARS text in PDF.**
Browse **the DFARS text in MS Word 7.** (To view in the correct format you must have the Century Schoolbook font.) Download Century schoolbook font.

Download **Zip files of the DFARS in PDF.**

Download **Zip files of the DFARS in MS Word.**

Search **either the current DFARS or previous versions of the DFARS (1998 Edition only).**

To receive the latest news of changes to the DFARS, subscribe to the DFARS News. The DFARS News will keep you informed by electronic mail about changes to the DFARS, proposed rules, public meetings, and other DFARS-related issues.

To recommend editorial changes to the DFARS, such as corrections of misspelled words, omitted words or lines, or errors in format, submit an electronic message to dfars@osd.mil . The message should include the DFARS citation and a complete description of the error. To recommend substantive changes to the DFARS, follow the instructions in DFARS 201.201-1(d).

DFARS Pub. Comments

Status of Open Cases

FAR

DFARS

Mgt. Status Report

FAQs

FAQs

Security & Privacy Disclaimer

Security & Privac Disclaimer

Back to the Defense Procurement Home Page, or go to ACQWeb, from the Under Secretary of Defense for Acquisition, Technology and Logistics.

FAX (703) 602-0350 **Site modified daily** EMAIL dfars@osd.mil

The content that you have tried to access was on a Web Site that has now been merged in to the DPAP Web Site.

You will be redirected to the DPAP homepage in a few seconds.

You may also click ahead. http://www.acq.osd.mil/dpap/

Acquisition Now | Acquisition Today | Knowledge Management | AKSS (Deskbook) | DAR Council | E-Business

Defense Procurement and Acquisition Policy

DPAP Seal - Bottom

Organization

Policies, Regulations, & Laws

Workforce, Training & Career Development

Industry Forums

Special Projects

Links

IRAQ Reconstruction

Donate to US Troops and

Federal Acquisition Regulation

ARNet HOME

FAR Reissue 2001 - PDF VOL I (For Printing Purposes Only)

FAR Reissue 2001 - PDF VOL II (For Printing Purposes Only)

All PDF Files Require Adobe Acrobat 5.0

Current FAR

Includes Amendments from FAC 24 effective July 19, 2004

- HTML Format
- PDF Format
- Frame Maker - Zipped
- FAR Matrix - HTML
- FAR Matrix - PDF
- FAR Index - PDF
- Appendix

FAR Reference

- FAR (Archived) - HTML
- FAR (Archived) - PDF
- GSA Forms Library
- FAR - Zipped
- Search the FAR

FAR Documents

- Proposed Rules
- Public Comments
- FACs - Looseleaf
- FACs - Federal Register
- Small Entity Compliance Guides

Other Information

- Subscribe to FAR News
- Frequently Asked Questions
- Authority of the FAR
- FAR Drafting Guide
- E-Handouts

For Persons with Disabilities

Search Contact Us Site Map What's New

Carnegie Mellon
Software Engineering Institute

Quick Search

GO

The right software, delivered defect free, on time and on cost, every time.

Select a topic

GO

ABOUT THE SEI

Our Sponsor
Carnegie Mellon
SEI-Europe
Permissions

SEI AREAS OF WORK

Management
Engineering
Acquisition

WORK WITH US

Contracting
Employment Opportunities
Licensing

PRODUCTS AND SERVICES

Conferences & Events
Education & Training
Licensed Providers
Membership Program

PUBLICATIONS

Addison-Wesley SEI Series
Annual Report
news@sei
Technical Reports

For more information about the SEI, its products, services, courses, and events, contact

Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213-3890
412-268-5800
http://www.sei.cmu.edu

SEI Headlines

TCS America Joins International Process Research Consortium

Carnegie Mellon University Names Paul D. Nielsen Director of the Software Engineering Institute

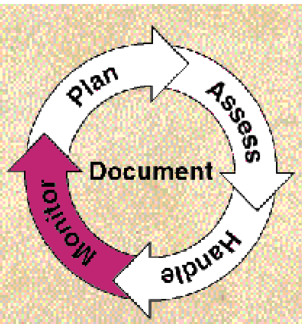
Register for Third Software Product Line Conference (SPLC 2004), to Be Held in Boston, August 30—September 2

First Three Keynote Speakers Announced for SEPG 2005, the Premier Process Improvement Conference

Software Engineering Information Repository (SEIR) Membership Soars

SEI Public and Media Relations

Search | Contact Us | Site Map | What's New | About the SEI | SEI Areas of Work
Work with Us | Products and Services | Publications | Terms of Use



Risk Management

U.S. DoD/DS/SE

Policies and Procedures

Related Websites

Related Publications

Papers and Speeches

Systems Engineering Homepage

Events | *Tools and Products*

Description:

Risk Management is a systematic approach to identifying, analyzing, and controlling areas or events with a potential for causing unwanted change. It is through risk management that risks to the program are assessed and systematically managed to reduce risk to an acceptable level.

Definitions:

Risk is a measure of the inability to achieve overall program objectives within defined cost, schedule, and technical constraints and has two components: (1) the probability of failing to achieve a particular outcome and (2) the consequences of failing to achieve that outcome.

Risk Management is the act or practice of controlling risk. It includes risk planning, assessing risk areas, developing risk-handling options, monitoring risks to determine how risks have changed, and documenting the overall risk management program.

****

Risk has always been a concern in the acquisition of DoD systems. The acquisition process itself is designed, to a large degree, to allow managers to control events, or their consequences, that might adversely affect a program. In the past, many managers viewed risk as something to be avoided and required that any program that had risk areas be subjected to review and oversight. This attitude has changed. DoD decision makers recognize that risk is inherent in

programs, and a goal of DoD acquisition is to study future program events, identify potential risks, and take measures to control them and ensure favorable outcomes.

There is no one standard approach for risk management. The approach taken must be tailored to the specific program taking into account program constraints and the acquisition strategy. There are some common elements of successful risk management efforts:

- Recognition that risk management is a program management responsibility

- The risk management process includes:

  - planning for risk management,

  - continuously identifying, analyzing program events,

  - assessing the likelihood of their occurrence and consequences,

  - incorporating handling actions to control risk events,

  - and monitoring a program's progress toward meeting program goals.

The Systems Engineering group, within Interoperability (IO) organization is responsible for risk management in DoD and has, at the direction of the Undersecretary of Defense, Acquisition, Technology, and Logistics (USD (AT&L)), examined DoD's approach to managing risk. Systems Engineering formed a Working Group (RMWG), composed of representatives from the Services and other DoD agencies involved in systems acquisition, to assist in the evaluation of the Department's approach to risk management. The results were briefed to the Defense Manufacturing Council (DMC), which directed DTSE&E to incorporate any guidance and advice in the Defense Acquisition Deskbook (DAD). The DAD, Section 2.5.2, Risk Management, is the result. This work also provided the basis for the Risk Management Guide produced by the OSD, Defense Acquisition University (DAU), and Defense Systems Management College (DSMC).

The Working Group will continue to provide a forum for sharing experiences and knowledge in order to provide Program Managers with the latest tools and advice on managing risk. You are invited to share your experiences and seek advice on the latest techniques.

SE CoP

Systems Engineering Community Of Practice (SE CoP) - The SE CoP is one of six communities of practice (and 10 special interest areas) located in the "Acquisition Community Connection (ACC)" website. The ACC was designed for the purpose of providing authoritative acquisition, technology and logistics information and access to experts and peers working on critical AT&L processes.

Have a Question? ... Ask a professor

Point of Contact

This Page Last Updated: undefined NaN, NaN

Office of the Under Secretary of Defense (Acquisition, Technology and Logistics) / Defense Systems

OUSD (AT&L)

Office of Defense Systems

Systems Engineering

DoD Privacy & Security Notice

NOTE: The Systems Engineering website is currently being revised to reflect the new Defense Systems organization

- **SE Mission** **(currently being revised)**
- **SE Key Areas of Responsibility:**
  - **Configuration and Data Management**
  - **DAWIA (Training and Education)**
  - **Integrated Product and Process Development (IPPD)**
  - **Manufacturing and**
  - **Reliability and Maintainability (R&M)**
  - **Risk Management**

- [Production]
- [Quality]
- [Reduction of Total Ownership Costs (RTOC)]
- [Software Engineering]
- [Systems Engineering]
- [Test and Evaluation]
- [Value Engineering]

- **Adopted Non-Government Standards**
- **SE Rotational Training Positions**

Point of Contact

This Page Last Updated: undefined NaN, NaN

LOGISTICS
AIR 3.0

The NAVAIR Logistic Competency is proud to announce the new NAVAIR Logistics Website. This new site will serve as the central location for all publicly accessible logistics information within NAVAIR. The content of the new site will grow dramatically over the next several weeks as consolidation and new pages are added. Please update your bookmarks accordingly. Our goal is to serve our customers better, please be patient during the transition period. Click the following link to manually redirect to the new NAVAIR Logistics Website (https://logistics.navair.navy.mil/).

Please Note - The Department of Defense (DoD) has mandated all unclassified Navy private web servers implement client-side authentication via DoD Public Key Infrastructure (PKI) identity certificates. PKI is a technology that enables secure transmission of data across computer networks - providing such security services as authentication, identification, confidentiality and data integrity.

Soon all access to the private servers linked off this public web site will be restricted to only those persons possessing valid DoD PKI certificates. See your Information System Security Manager (ISSM)/Information System Security Officer (ISSO) for information on obtaining and configuring your DoD user certificates for web access.

NAVAIR
NAVAL AIR SYSTEMS COMMAND

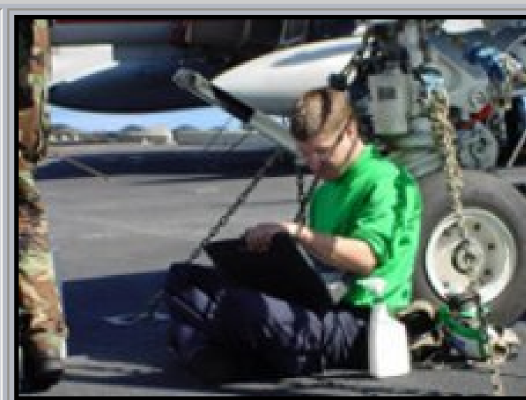
Search

Logistics (AIR 3.0) - Providing World-Class Support To The Warfighter

:: CONTACT US

About Us
Products

Library
Logistics Tools
Initiatives
Support
Training
Links
Site Index



QUICK LINKS

AIRSPEED

ELECTRONIC READINESS INTEGRATED IMPROVEMENT PROGRAM (eRIIP)

NALDA IDE Action Tracker

APML HANDBOOK

AV-3M REPORTS

NAVAIR ACQUISITION COMMAND SLATING PANEL

NAVY KNOWLEDGE ONLINE

NAVAIR RESPONSE CENTER

LOGISTICS NEWS

LOGISTICS CALENDAR

- July 26-30 Decisions and Risk Analysis for Complex Systems (NAS Pax River, MD)
- July 27&28 Logistics Exchange / Logistics Toolbox Overview (NAS Pax River, MD)
- July 29 Logistics Exchange Overview (Advanced)(NAS Pax River, MD)
- Aug 2-3 Readiness Based Sparing (RBS) (NAS Pax River, MD)
- Aug 9-13 Design Interface/

(NRC)

NAVAL AVIATION MAINTENANCE PROGRAM NAMP (OPNAVINST 4790)

NALCOMIS HOMEPAGE

US NAVY RECRUITING WEB SITE

Maintenance Planning (NAS Pax River, MD)

- **Aug 9-13 Eureka/Cognos Training (NAS Pax River, MD)**
- **Aug 17 Logistics Team Training (NAS Pax River, MD)**
- **Aug 24-26 Support Equipment (NAS Pax River, MD)**
- **Aug 30-Sept 03 Design for System Reliability, Maintainability and Supportability (NAS Pax River, MD)**
- **Sept 8-10 Joint Aviation Model for Level of Repair Analysis (JAM for Lora (NAS Pax River, MD)**
- **Sept 13-17 Product Support Fundamentals (NAS Pax River, MD)**
- **Sept 21 Logistics Team Training (NAS Pax River, MD)**

Welcome to ISO Online

International Organization for Standardization

***ISO*. The source of ISO 9000, ISO 14000 and more than 14 000 International Standards for business, government and society.**

***ISO*. A network of national standards institutes from 148 countries working in partnership with international organizations, governments, industry, business and consumer representatives. A bridge between public and private sectors.**

Français

enter

IEEE HOME | SEARCH IEEE | SHOP | WEB ACCOUNT | CONTACT IEEE

Membership Publications Services Standards Conferences Careers/Jobs

IEEE standardsonline

Your Direct Connection to IEEE Standards

Subscription Portfolio Features & Benefits Pricing & Licensing How to Order Help

IEEE-SA Links

» Welcome To IEEE Standards Online »

Tuesday, 27 July 2004

LOG-IN

ACCOUNT MAINTENANCE

- Register
- Renewal
- Change Password

SEARCH

- Search Subscriptions
- Standards Numerical Listing (Subscribers Only)
- Standards Status

ONLINE HELP

- Online Tutorial
- FAQs

NEWSROOM

- What's new @ IEEE
- Announcements

IEEE Standards Online News Headlines

IEEE Standards Online. It's Fast and Flexible

In Today's highly competitive business environment, where standards are key, and information is power, you can have it all at your finger tips with IEEE Standards Online. Our service includes your choice of 25+ topical subscriptions, plus...

- All-inclusive Standards Subscription--the entire portfolio of IEEE standards offering.
- Industry subscriptions--a subsection of the portfolio that focuses on the Power and Energy, Information Technology, Telecommunications and Transportation Industries.
- Ancillary Technical Subscriptions--a grouping of standards according to technical interests and application.

Visit http://standards.ieee.org/catalog/olis/subscription.html to place an order and to view our entire Subscription Portfolio.

Think Standards! Think IEEE!

Point-of-Care Medical Device Standards

The IEEE Standards Association (IEEE-SA) has approved standards on Health Care Informatics, Point of Care Medical Device Communication (IEEE 1073™ Series). This series of standards are also recognized by the ISO as ISO 10730. *find out more*

Visit our IEEE Medical Device Standards subscription package for a listing of available standards in this series.

2004 IEEE Int'l Symposium on EMC

The 2004 IEEE International Symposium of Electromagnetic Compatibility, will be held 9-13 August 2004, in Silicon Valley at the Santa Clara Convention Center, Santa Clara California.

Available for your convenience is an IEEE EMC Subscription package geared to help you prepare for this event.

New/revised standards added to Standards Online June/July 2004

NEW!

Register for FREE Newsletters

IEEE Standards Zones

Select zone

GET IEEE 802

Get IEEE 802 or Online Subscription:

- What's the difference?

Web Delivery of Individual Standards

-About

-Online Catalog and Store

IEEE's Corporate Membership Discount

Corporate/entity members of the IEEE Standards Association can receive up to **25% off** IEEE Standards Online Subscription.

Access to this subscription is fast and easy. **Subscribe Today!**

For a free demonstration of our products and services, visit the IEEE booths #1707 and #1708 located in the lobby near the registration area.

ACQUISITION GUIDE

NAVAIR
Training Systems Division Orlando Florida

Introduction	Guide Contents
What's New!	Search
Frequently Asked Questions	Point Of Contact
Acquisition Training	Download Documents

Advisors

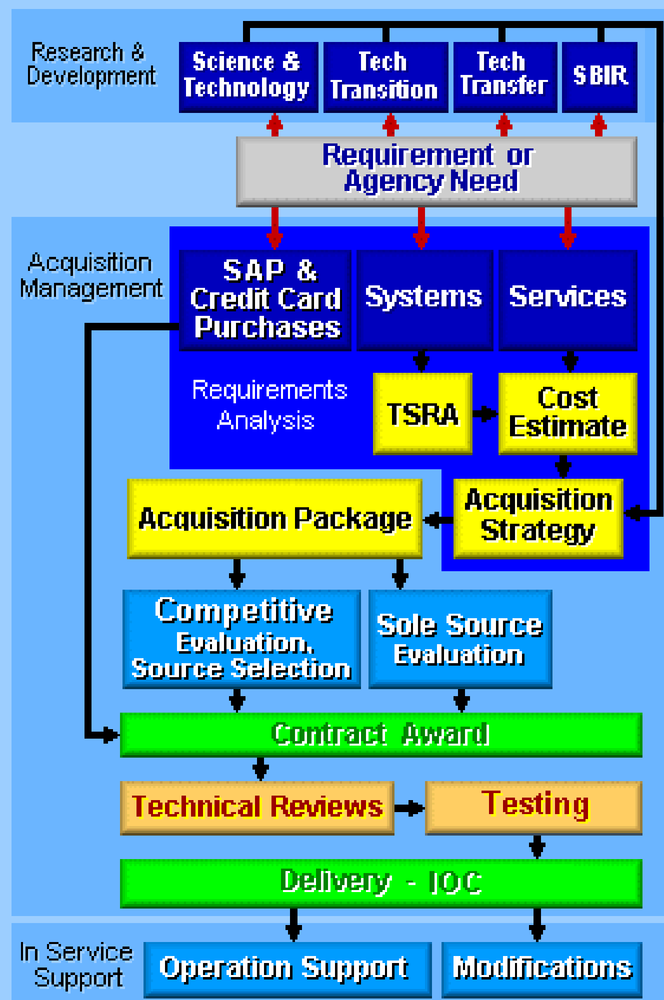
- Contracts
- Logistics
- Configuration Management
- Specifications and Standards
- Funding
- Contractors Advisor

Acquisition Topics

- Procurement Initiation Document/Procurement Request (PID/PR)
- Procurement Planning Conference (PPC)
- IQC Guide Book, Procedures and Check List
- Guide to Specification Writing
- Technical Data Management Program
- Standard Procurement System (SPS)
- Past Performance
- Integrated Product Teams (IPTs), Teaming, Partnering
- Interfacing With Industry
- Information Technology
- Simulation Based Acquisition (SBA)
- Earned Value Management (EVM)
- Single Process Initiative (SPI)
- Market Research
- Freedom Of Information Act (FOIA)

Acquisition Roadmap

Text Version   PowerPoint Version



Policies

NAVAIR TSD Competencies

- Acquisition Processes Office
- Contracts Standard Operating Procedures
- Engineering DOREMs And Joint Engineering/ILS Memorandums
- Comptroller
- Logistics Processes and Guidance

NAVAIR

- NAVAIR Instructions

Navy

- Navy Electronics Directives System (NEDS)

DoD

- Directives and Instructions

DoD & SECNAV 5000 Series Documents, Joint Chiefs of Staff Documents

- OSD Acquisition Policy Web Site
- DAU DOD 5000 Series Resources Center
- ACAT Review DoD Inst 5000.2, SECNAV Inst 5000.2C
- 5000.2B SECNAV Instruction 5000.2B (Dec 6, 1996) (pdf)
- CJCSM 3170.01 Operation of the Joint Capabilities Integration and Development System
- CJCSI 3170.01C Joint Capabilities Integration and Development System

Acquisition Related Web Sites

- DoD Procurement & Acquisiton Policy
- OUSD - AcqWeb
- ASSIST MIL-SPECs, MIL-STDs, DIDs
- OFPP Best Practices
- Navy Acquisition Reform Office
- Navy Turbo Streamliner
- Navy Acquisition Business Mgmt Home Page
- NAVAIR Acquisition Guide
- NAVAIR Team Process Toolkit
- Naval Acquisition Career Mgmt
- AT&L Knowledge Sharing System
- Acquisition Community Connection
- Acquisition Reform Network (ARNET)
- Defense Standardization Program
- Army Acquisition Policy and Procurement
- Air Force Acquisition
- Air Force Acquisition Center Of Excellence
- Air Force Deskbook
- Air Force Knowledge Now
- FAA Acquisition System Toolset